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Center for Night Vision and Electro-Optics

AMSEL-NV-TR-0081

AD-A214 394

ENVIRONMENTAL EVALUATION OF THE RICOR/CRYO-TEK 1/4-WATT SPLIT COOLER (CT-45)

by

H. Dunmire
R. Samuels
J. Shaffer

SEPTEMBER 1989

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SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
1a. REPORT SECURITY CLASSIFICATION Unclassified			1b. RESTRICTIVE MARKINGS None		
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.		
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE					
4. PERFORMING ORGANIZATION REPORT NUMBER(S) AMSEL-NV-TR-0081			5. MONITORING ORGANIZATION REPORT NUMBER(S)		
6a. NAME OF PERFORMING ORGANIZATION CECOM, Center for Night Vision and Electro-Optics (C ² NVEO)		6b. OFFICE SYMBOL (If applicable) AMSEL-RD-NV-SES		7a. NAME OF MONITORING ORGANIZATION	
6c. ADDRESS (City, State, and ZIP Code) Director, C ² NVEO ATTN: AMSEL-RD-NV-SES Fort Belvoir, VA 22060-5677			7b. ADDRESS (City, State, and ZIP Code)		
8a. NAME OF FUNDING/SPONSORING ORGANIZATION C ² NVEO		8b. OFFICE SYMBOL (If applicable)		9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER	
8c. ADDRESS (City, State, and ZIP Code)			10. SOURCE OF FUNDING NUMBERS		
			PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.
			WORK UNIT ACCESSION NO.		
11. TITLE (Include Security Classification) Environmental Evaluation of the RICOR/CRYO-TEK 1/4-Watt Split Cooler (CT-45) (U)					
12. PERSONAL AUTHOR(S) H. Dunmire, R. Samuels, and J. Shaffer					
13a. TYPE OF REPORT Final		13b. TIME COVERED FROM 4/18/88 TO 7/21/88		14. DATE OF REPORT (Year, Month, Day) September 1989	
15. PAGE COUNT 130					
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP			
			Cryocooler, Stirling Cycle, Clearance Seal, Cryogenics		
19. ABSTRACT (Continue on reverse if necessary and identify by block number)					
<p>This final report describes and provides the data on the environmental testing of the RICOR/CRYO-TEK 1/4-Watt Split Stirling Cooler (HD-1045(V)/UA). Other vendor 1/4-Watt Split Coolers are currently used in the Bradley Fighting Vehicle FLIR and the M1 Driver Thermal Viewer. C²NVEO evaluated the cooler performance at environmental extremes per the development specification B2-28A050122A.</p>					
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input checked="" type="checkbox"/> SAME AS REPORT <input type="checkbox"/> DTIC USERS				21. ABSTRACT SECURITY CLASSIFICATION Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL James Shaffer				22b. TELEPHONE (Include Area Code) 703-664-1345	
				22c. Office Symbol AMSEL-RD-NV-SES	

DD Form 1473, JUN 88

Previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

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DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
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Availability Codes	
Dist	Avail and/or Special
A-1	



SECTION I. INTRODUCTION

The US Army CECOM Center for Night Vision and Electro-Optics (C²NVEO) is responsible for developing cryogenic coolers for all infrared imaging systems for the Army. C²NVEO also maintains configuration management control of the forward-looking infrared (FLIR) Common Module coolers used in thermal imagers in fielded Army weapon systems such as: M60A3 and M1 Tanks, Bradley Fighting Vehicle System, tube-launched, optically tracked, wire-guided (TOW) Missile System, and Army Attack Helicopters. Currently, there are over 30,000 coolers in fielded systems and several thousand more are added each year. C²NVEO conducts development programs and monitors contractor internal research and development efforts to improve cooler performance such as reliability, audio noise, power consumption, and output vibration. One of these efforts has been the development of a clearance seal HD-1045 cooler for the potential use in the tank and helicopter FLIRs.

The HD-1045 1/4-Watt Split Stirling Cooler was originally designed and developed by the CECOM Center for Night Vision and Electro-Optics (C²NVEO) in the early 1970s as a replacement for the gas bottle/cryostat used on the Manportable Common Thermal Night Sights. To date, however, the HD-1045 cooler has been used in the field in the Integrated Sight Unit (ISU) of the Bradley Fighting Vehicle (BFV) System.

Performance requirements for the HD-1045 are governed by the cooler specification, B2-28A050122A, dated 18 June 1982. The primary specification requirements for this cooler include the ability to maintain a 0.35-watt heat load at 85K at room temperature, cooldown a 1.8 gram copper mass to 85K within 10 minutes over the temperature range of -40°C to +71°C, and operate under steady state conditions with a 0.35 watt heat load applied at room temperature with a power consumption of 30 watts or less.

This report describes the performance and environmental testing that C²NVEO conducted on the RICOR/CRYO-TEK Coolers. The test procedure used throughout the evaluation, "Qualification Test Procedure 1/4-Watt Split Stirling Cooler," has been included in Appendix A for reference. The RICOR/CRYO-TEK coolers have not been subjected to life testing, therefore no mean time to failure (MTTF) is available. The MTTF testing and determination are required prior to the decision being made on whether the coolers are acceptable for use or not.

SECTION II. DESCRIPTION

The environmental evaluation was conducted on two RICOR/CRYO-TEK coolers, S/N 8011 and S/N 013 in accordance with the Qualification Test Procedure in Appendix A. Baseline acceptance tests and leak rates were conducted before and after each environmental test to determine whether or not the units had survived the test. In addition to the environmental tests, C²NVEO conducted audible noise and vibration output testing on the coolers.

A brief description of each test performed is provided in Table 1.

Table 1. Test Description

TEST	REQUIREMENT
Leak Rate	Less than 1.0×10^{-6} std cc/sec helium
Acceptance Test	
— Cooldown	Less than 7.5 min to 100K Less than 10 min to 85K
— Cooling Capacity	0.35 Watt at 85K
— Input Power	Less than 30 watts
Acoustic Noise	Sound pressure levels must be less than specified limits between 125 to 8,000 Hz
Vibration Output	No requirement
Temperature Shock	Rapid temperature changes from -54°C to +71°C every 4 hours for 24 hours total
High Temperature	48 hour soak at +71°C, +71°C operation
Low Temperature	24 hour soak at -57°C, -40°C operation
Mechanical Shock	100 g's peak amplitude for 11 msec
Imposed Vibration	4-5 g's acceleration over 5 to 500 Hz

SECTION III. TEST RESULTS

Both coolers failed audible noise testing at Noise Unlimited and C²NVEO. The coolers exceeded the specification maximum sound pressure levels at 2,000, 4,000, and 8,000 Hz. The vibration output testing was conducted for information purposes; there is no specification requirement. All the environmental tests were successfully completed by S/N 8011 and S/N 013. There were no failures, relevant or otherwise, and all environmental tests were completed without incident. A brief summary of all acceptance testing is shown in Tables 2 and 3.

Table 2. Environmental Test Results S/N 8011

TEST	COOLDOWN 80K (min)	TEMP (K) WITH HEAT LOAD	POWER (WATTS)	LEAK RATE scc He/sec
Initial Baseline	4.00	75.27	23.00	1.0×10^{-9}
Post Mechanical Vibration	3.88	76.43	22.78	2.5×10^{-9}
Post Temperature Shock	3.93	74.82	23.11	2.6×10^{-10}
High Temperature	6.00	83.46	23.83	—————
Post High Temperature	3.77	76.66	22.42	8.0×10^{-9}
Low Temperature	2.43	62.12	19.65	—————
Post Low Temperature	3.67	73.24	22.81	9.0×10^{-9}
Post Mechanical Shock	3.67	71.00	22.80	7.5×10^{-9}

Table 3. Environmental Test Results S/N 013

TEST	COOLDOWN 80K (min)	TEMP (K) WITH HEAT LOAD	POWER (WATTS)	LEAK RATE scc He/sec
Initial Baseline	3.87	77.00	21.16	2.8×10^{-9}
Post Mechanical Vibration	3.23	71.46	21.69	2.3×10^{-9}
Post Temperature Shock	3.30	70.20	21.57	6.4×10^{-10}
High Temperature	4.43	69.13	23.25	—————
Post High Temperature	3.65	75.13	21.49	7.0×10^{-9}
Low Temperature	2.53	63.43	19.12	—————
Post Low Temperature	3.32	70.13	21.74	7.9×10^{-9}
Post Mechanical Shock	3.22	71.65	21.4	5.4×10^{-9}

APPENDIX A TEST DATA

All environmental test data shown in this appendix appears in chronological order, as the tests were conducted. The acoustic noise test data (pages A-46 through A-57) and vibration output data (pages A-58 through A-74) are provided. All cooler testing was conducted using a 1.8 gram copper mass coldstation and an input voltage of 17.5 VDC.

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INITIAL BASELINE—S/N 013

MODEL DR-06GEN10 COOLER LAB

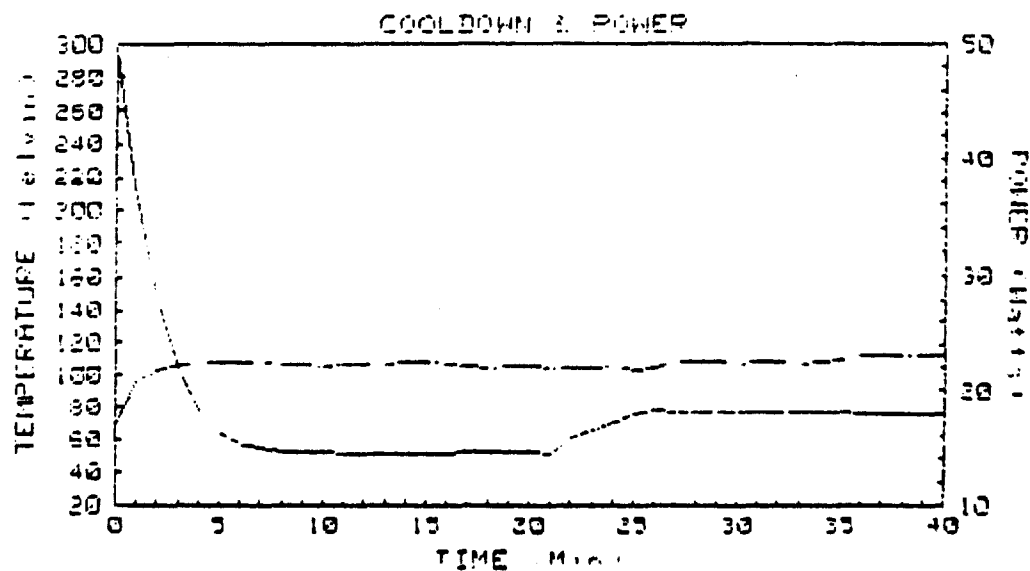
DR-06GEN10 COOLER DATA

COOLER: R100R/OT-45 6011
VOLTAGE: 115.5
AMBIENT:

DATE: 18 APRIL 68 23.4
ENGR: FLD
PROG. DATA: 10

TEST: BASELINE TEST AS RECEIVED *

TIME	POWER	CURRENT	TEMP IN	LOAD
0.00	16.83	1.265	235.33	0.222
1.00	20.86	1.218	208.21	0.222
2.00	21.72	1.256	148.35	0.222
3.00	22.20	1.276	104.35	0.222
3.25	22.29	1.273	98.15	0.222
4.00	22.36	1.266	79.13	0.222
4.13	22.50	1.261	77.15	0.222
5.00	22.55	1.266	64.51	0.222
6.00	22.55	1.266	57.12	0.222
7.00	22.43	1.273	53.96	0.222
8.00	22.26	1.271	52.44	0.222
9.00	22.25	1.276	51.70	0.222
10.00	22.14	1.262	51.43	0.222
11.00	22.37	1.261	50.31	0.222
12.00	22.37	1.260	50.31	0.222
13.00	22.41	1.261	51.09	0.222
14.00	22.43	1.264	51.05	0.222
15.00	22.43	1.266	51.31	0.222
16.00	22.39	1.267	51.00	0.222
17.00	22.20	1.270	51.61	0.222
18.00	22.04	1.266	51.67	0.222
19.00	22.13	1.267	51.74	0.222
20.00	22.14	1.267	51.57	0.222
30.00	22.42	1.262	77.00	.353
40.00	23.00	1.317	75.27	.354



INITIAL BASELINE—S/N 013

WELL FROGENIC COOLER L-6

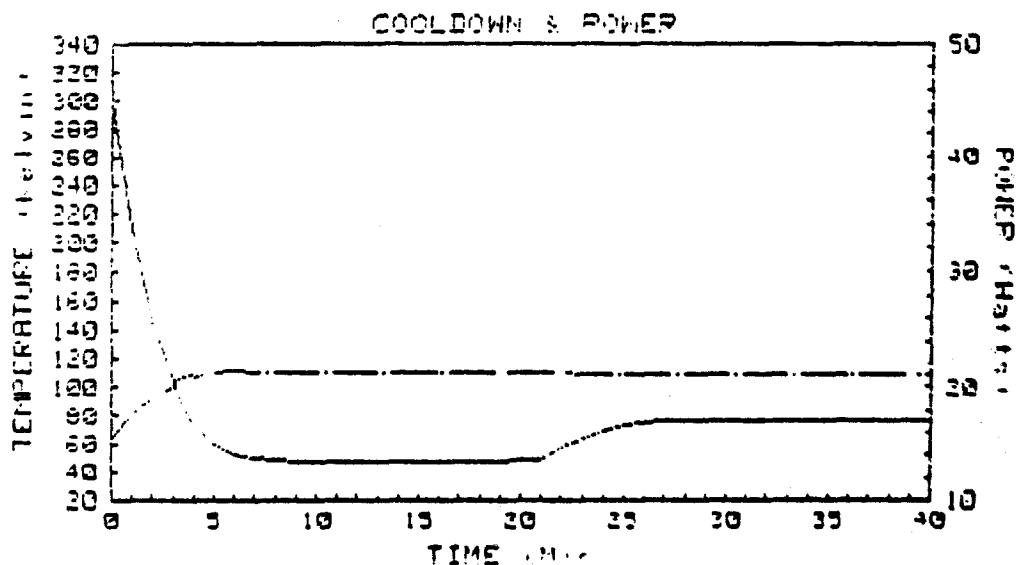
FROGENIC COOLER DATA

COOLER, FROGENIC 07-45 013
 VOLTAGE, 17.5
 AMBIENT,

DATE, 5 APRIL 68 05.30
 ENGR, L-3
 PROJ, DATA, 1.2

TEST, BASELINE TEST AS RECEIVED *

TIME	POWER	CURRENT	REL. IN	LOAD
0.00	15.52	1.037	70.54	0.000
1.00	17.83	1.039	70.52	0.000
2.00	16.90	1.038	67.85	0.000
3.00	20.01	1.073	74.70	0.000
4.00	20.62	1.090	65.54	0.000
5.00	21.15	1.206	77.84	0.000
6.00	21.01	1.221	74.50	0.000
7.00	21.36	1.225	68.93	0.000
8.00	21.37	1.217	62.85	0.000
9.00	21.33	1.217	49.13	0.000
10.00	21.31	1.215	47.97	0.000
11.00	21.34	1.222	47.47	0.000
12.00	21.31	1.214	47.43	0.000
13.00	21.30	1.220	47.26	0.000
14.00	21.34	1.221	47.33	0.000
15.00	21.29	1.218	47.12	0.000
16.00	21.34	1.218	47.43	0.000
17.00	21.30	1.224	47.30	0.000
18.00	21.34	1.220	47.21	0.000
19.00	21.35	1.215	47.26	0.000
20.00	21.31	1.220	47.26	0.000
21.00	21.30	1.218	47.43	0.000
22.00	21.26	1.225	47.60	0.000
30.00	21.09	1.207	75.63	.353
40.00	21.16	1.209	77.00	.353



LEAK RATE TEST DATA SHEET

Test Tech HLD Project Eng. _____

Date _____ Time _____

TEST REQUIREMENT

Conduct Leak Rate Test per paragraph 6.1.1 of this plan.

15 APR 88 _____

Cooler S/N 013
Charged to operating pressure _____ (initial)
Measured leak rate (1.0×10^{-6} scc/sec air
equivalent at 23C ambient) 2.8×10^{-9}

Cooler S/N 8011
Charged to operating pressure _____ (initial)
Measured leak rate (1.0×10^{-6} scc/sec air
equivalent at 23C ambient) 1.0×10^{-9}

Cooler S/N _____
Charged to operating pressure _____ (initial)
Measured leak rate (1.0×10^{-6} scc/sec air
equivalent at 23C ambient) _____

Test Sheet 2

PHYSICAL CHARACTERISTICS DATA SHEET

Test Tech HLD

Date 19 APR 88
Project Eng.

REQUIREMENT

Record the following physical characteristics per paragraph 5.0 of this test plan.

Cooler S/N 013

Conforms to drawing number

SM-D-808551

Weight (2.5 pounds Max.)

____ (initial)
1.837 lb.

Cooler S/N 8011

Conforms to drawing number

SM-D-808551

Weight (2.5 pounds max.)

____ (initial)
0.795 lb.

Cooler S/N _____

Conforms to drawing number

SM-D-808551

Weight (2.5 pounds max.)

____ (initial)
____ lb.

Test Sheet 1

MECHANICAL VIBRATION

NIGHT VISION



DEPARTMENT OF THE ARMY
ARMY NIGHT VISION AND ELECTRO-OPTICS LABORATORY
FORT BELVOIR, VIRGINIA 22060

TEST REPORT

RICOR COOLERS

S/N's 013 AND 8011

22 MAY 1968

A-6

TEST ITEMS

RICOR Coolers, S/N's 013 and 8011

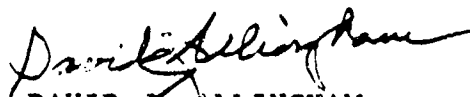
TEST SPECIFICATION

B2-28A050122A, 18 June 1982

TEST DESCRIPTION

Both coolers were fastened to a rigid fixture and vibrated on three mutually perpendicular axes. The vibration was sinusoidal and its amplitude and frequency were controlled per para 4.3.2.3 and figure 3 of the above cited specification.

Both coolers continued to operate during all tests and maintained a frosted cold finger.


DAVID J. ALLINGHAM
Test Coordinator
Support Operations Team
Technical Support Division
Center for Night Vision and
Electro-Optics

B2-28A050122A
CODE IDENT: 54490
18 JUNE 1982

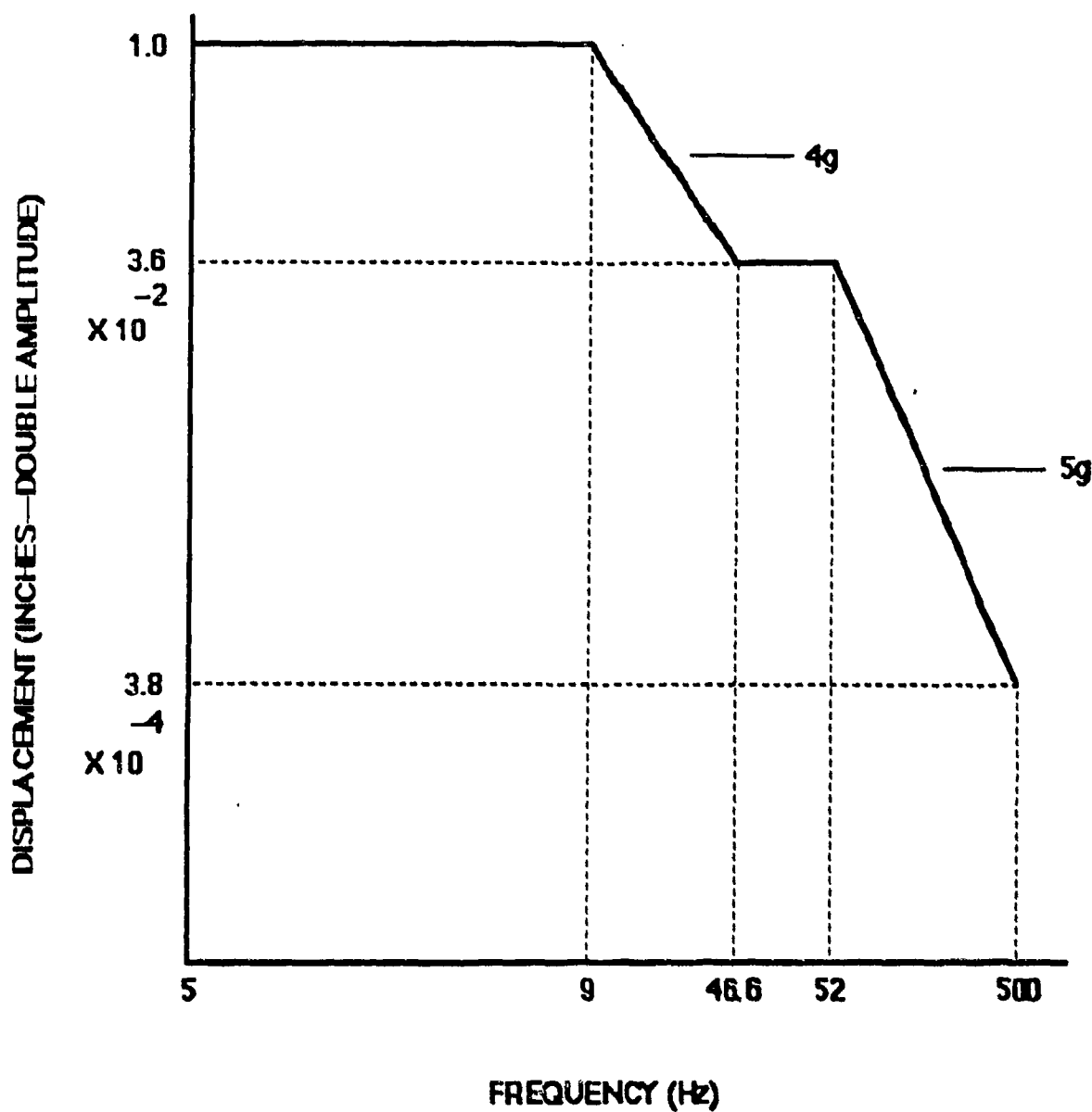


Figure 3. Vibration Test Profile

MECHANICAL VIBRATION—S/N 8011

MECHANICAL VIBRATION TEST SUMMARY SHEET

Cooler S/N 8011Date of Test 10/1/88Test Tech David AllingtonProj. Eng. W. J. Carter

Step	Test Requirement	Initial
1.0	Mount cooler onto vibration table in the X axis.	<u>1</u>
2.0	Energize coolers and allow cooldown for 10 minutes.	<u>2</u>
3.0	Energize vibration machine and conduct a resonance search at an input level of 1g from 5- 500 Hz.	<u>3</u>
Resonances: 1. <u> </u> 2. <u> </u> 3. <u> </u> 4. <u> </u> 5. <u> </u> 6. <u> </u> 7. <u> </u>		
4.0	Select the four most severe resonances recorded and perform a resonance dwell for 20 minutes frequency levels specified.	<u>4</u>
5.0	Energize vibration machine in accordance to the vibration profile.	<u>5</u>
6.0	Allow coolers to vibrate in this axis for 120 minutes	<u>6</u>
7.0	De-energize vibration machine and coolers	<u>7</u>
8.0	Remove coolers from vibration machine and inspect for physical damage.	<u>8</u>
9.0	Mount the coolers in the Y axis and repeat steps 2.3 and 4	<u>9</u>
10.0	Energize the coolers and allow cooldown for 10 minutes	<u>10</u>
11.0	Energize the vibration machine in accordance with the appropriate vibration profile.	<u>11</u>
12.0	Allow the cooler to vibrate in this axis for 120 minutes.	<u>12</u>
13.0	De-energize vibration machine and remove the coolers. Inspect the coolers for any physical damage.	<u>13</u>
14.0	Mount the coolers in the Z axis. instrumented. repeat steps 2.3 and 4 in the Z axis.	<u>14</u>
15.0	Energize the coolers and allow to cooldown for 10 minutes.	<u>15</u>

MODEL CRYOGENIC COOLER L-6

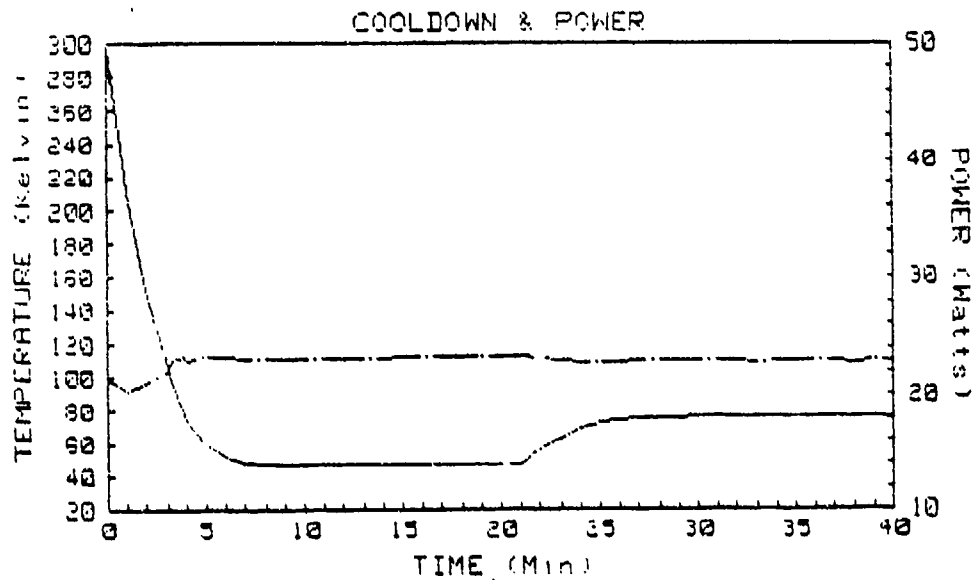
CRYOGENIC COOLER DATA

COOLER: RIGORACT-45 8011
VOLTAGE: 17.5
AMBIENT: 23 (C)

DATE: 7 JUNE 68 15:13
ENGR: HLD
DEWAR COMP: .335

TEST: BASELINE TEST FOLLOWING MECHANICAL VIBRATION

TIME	POWER	CURRENT	RELVIN	LOAD
0.00	21.35	1.320	257.09	0.000
1.00	20.25	1.173	211.75	0.000
2.00	20.98	1.221	152.24	0.000
3.00	22.00	1.305	105.97	0.000
3.25	22.91	1.309	97.96	0.000
3.66	23.14	1.322	78.12	0.000
4.00	22.91	1.307	74.82	0.000
5.00	23.13	1.324	59.15	0.000
6.00	23.26	1.333	51.97	0.000
7.00	23.03	1.323	48.97	0.000
8.00	23.04	1.304	47.62	0.000
9.00	22.97	1.323	47.09	0.000
10.00	22.99	1.315	46.68	0.000
11.00	22.99	1.311	46.79	0.000
12.00	23.07	1.318	46.63	0.000
13.00	23.02	1.316	46.92	0.000
14.00	23.08	1.326	46.75	0.000
15.00	23.22	1.328	46.63	0.000
16.00	23.21	1.320	46.96	0.000
17.00	23.21	1.332	47.05	0.000
18.00	23.20	1.324	47.05	0.000
19.00	23.16	1.322	47.18	0.000
20.00	23.15	1.316	47.23	0.000
30.00	22.88	1.309	76.32	.354
40.00	22.78	1.296	76.43	.354



MECHANICAL VIBRATION TEST SUMMARY SHEET

Cooler S/N 013Date of Test 18 May 88Test Tech David AllinghamProj. Eng. Jim Shaffer

Step	Test Requirement	Initial
1.0	Mount cooler onto vibration table in the X axis.	<u>JA</u>
2.0	Energize coolers and allow cooldown for 10 minutes.	<u>JA</u>
3.0	Energize vibration machine and conduct a resonance search at an input level of 1g from 5- 500 Hz.	<u> </u>
Resonances: 1. <u> </u> 2. <u> </u> 3. <u> </u> 4. <u> </u> 5. <u> </u> 6. <u> </u> 7. <u> </u>		
4.0	Select the four most severe resonances recorded and perform a resonance dwell for 20 minutes frequency levels specified.	<u> </u>
5.0	Energize vibration machine in accordance to the vibration profile.	<u>JA</u>
6.0	Allow coolers to vibrate in this axis for 120 minutes	<u>JA</u>
7.0	De-energize vibration machine and coolers	<u>JA</u>
8.0	Remove coolers from vibration machine and inspect for physical damage.	<u>JA</u>
9.0	Mount the coolers in the Y axis and repeat steps 2,3 and 4	<u> </u>
10.0	Energize the coolers and allow cooldown for 10 <u>5</u> minutes	<u>JA</u>
11.0	Energize the vibration machine in accordance with the appropriate vibration profile.	<u>JA</u>
12.0	Allow the cooler to vibrate in this axis for 120 minutes.	<u>JA</u>
13.0	De-energize vibration machine and remove the coolers. Inspect the coolers for any physical damage.	<u>JA</u>
14.0	Mount the coolers in the Z axis, instrumented, repeat steps 2,3 and 4 in the Z axis.	<u> </u>
15.0	Energize the coolers and allow to cooldown for 10 <u>5</u> minutes.	<u>JA</u>

Step	Test Requirement	Initial
16.0	Energize the vibration machine with the appropriate vibration profile.	<u>AB</u>
17.0 minutes	Allow the coolers to vibrate in this axis for 120 minutes	<u>AB</u>
18.0	De-energize the vibration machine and remove the coolers. Inspect the coolers for any physical damage.	<u>AB</u>
19.0	Conduct a performance test per paragraph 6.0	<u>AB</u>

Leak Test: 2.3×10^{-9} Std cc helium/sec

Comments _____

INVEST CRYOGENIC COOLER LAB

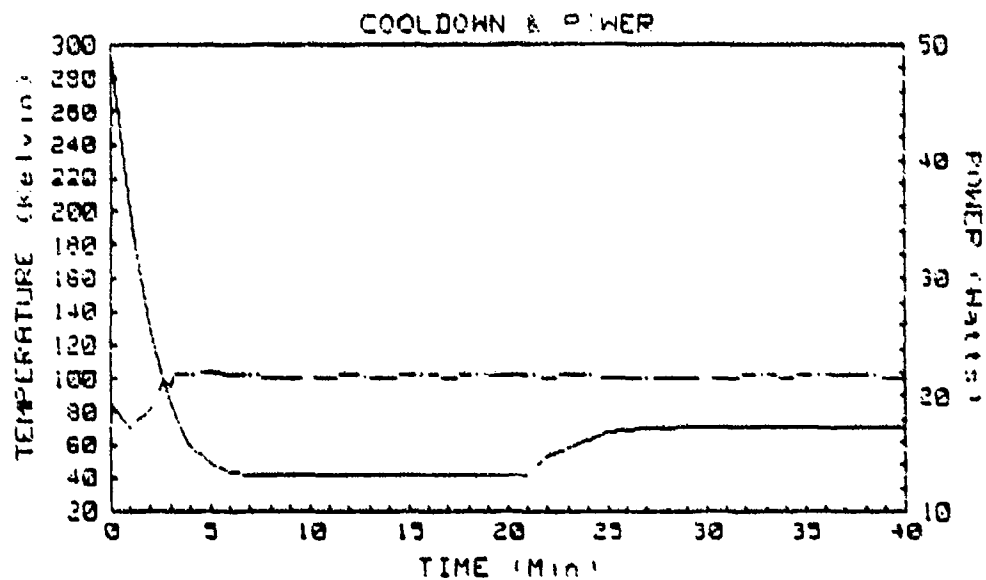
CRYOGENIC COOLER DATA

COOLER: RIGOR/CT-45 013
VOLTAGE: 17.5
AMBIENT: 23 (C)

DATE: 7 JUNE 68 09:09
ENGR: HLO
DEWAR COMP: .335

TEST: BASELINE TEST FOLLOWING MECHANICAL VIBRATION

TIME	POWER	CURRENT	KELVIN	LOAD
0.00	19.13	1.093	293.63	0.000
1.00	17.25	1.043	200.19	0.000
2.00	16.89	1.131	131.35	0.000
2.67	21.02	1.201	99.98	0.000
3.00	20.74	1.237	85.68	0.000
3.23	21.81	1.246	78.66	0.000
4.00	21.89	1.272	59.47	0.000
5.00	21.95	1.253	46.53	0.000
6.00	21.82	1.254	44.04	0.000
7.00	21.80	1.252	42.43	0.000
8.00	21.67	1.231	42.04	0.000
9.00	21.70	1.228	41.91	0.000
10.00	21.66	1.226	41.78	0.000
11.00	21.64	1.229	41.95	0.000
12.00	21.76	1.235	41.95	0.000
13.00	21.69	1.224	42.04	0.000
14.00	21.67	1.220	42.17	0.000
15.00	21.79	1.249	42.08	0.000
16.00	21.75	1.253	42.00	0.000
17.00	21.68	1.223	42.08	0.000
18.00	21.76	1.257	42.04	0.000
19.00	21.88	1.255	42.17	0.000
20.00	21.82	1.242	42.26	0.000
30.00	21.60	1.237	71.58	.354
40.00	21.69	1.236	71.46	.354



LEAK RATE TEST DATA SHEET

Test Tech G. DOGGETT Project Eng. _____

Date _____ Time _____ TEST REQUIREMENT

Conduct Leak Rate Test per paragraph 6.1.1 of this plan.

9 Jun 88

Cooler S/N 013
Charged to operating pressure _____ (initial)
Measured leak rate (1.0×10^{-6} scc/sec air
equivalent at 23C ambient) 2.3×10^{-9}

Cooler S/N 8011
Charged to operating pressure _____ (initial)
Measured leak rate (1.0×10^{-6} scc/sec air
equivalent at 23C ambient) 2.5×10^{-9}

Cooler S/N _____
Charged to operating pressure _____ (initial)
Measured leak rate (1.0×10^{-6} scc/sec air
equivalent at 23C ambient) _____

MEASUREMENTS TAKEN FOLLOWING THE
MECHANICAL VIBRATION TEST.

Test Sheet 2

TEMPERATURE SHOCK—S/N 8011

TEMPERATURE SHOCK TEST SUMMARY SHEET

Cooler S/N 8011Date: 9 JUNE 88Test Tech. HLD

Project Eng. _____

Step	Date	Elapsed Time	Test requirement	Initial
1.0	<u>9 JUN</u>	<u>10:50</u>	Install coolers into test chamber	<u>HLD</u>
2.0		<u>10:50</u>	Adjust chamber ambient to + 71C	<u>HLD</u>
3.0		<u>15:15</u>	verify cooler has soaked for four hours	<u>JKS</u>
4.0		<u>15:15</u>	Place cooler into test chamber that has been pre-cooled to -34C within 5 minutes from 71C	<u>JKS</u>
5.0		<u>19:15</u>	Verify cooler has soaked for four (4) hours at -34C	<u>HLD</u>
6.0		<u>19:15</u>	Place cooler into test chamber that has been pre-heated to 71C within 5 mins. of removing from -34C ambient.	<u>HLD</u>
7.0		<u>23:15</u>	Verify cooler has soaked for four hours at +71C	<u>HLD</u>
8.0		<u>23:15</u>	Place cooler into test chamber that has been pre-cooled to -34C within 5 mins. of removing from +71C ambient.	<u>HLD</u>
9.0	<u>10 JUNE</u>	<u>3:15</u>	Verify cooler has soaked for four hours at -34C	<u>HLD</u>
10.0		<u>3:15</u>	Place cooler into test chamber that has been pre-heated to +71C within 5 mins. of removing from -34C ambient.	<u>HLD</u>
11.0		<u>7:15</u>	Verify cooler has soaked for four hours at +71C	<u>JKS</u>
12.0		<u>7:15</u>	Place cooler into test chamber that has been pre-cooled to -34C within 5 mins. of removing from +71C ambient.	<u>JKS</u>

Temperature Shock Test Summary Sheet (Continued)

Step	Date	Elapsed Time	Test Requirement	Initial
13.	10 JUNE	11:15	Verify cooler has soaked for four hours.	AKS
14.		11:15	Adjust test chamber ambient to +23C	AKS
15.		13:00	Verify test chamber Ambient is 23C	AKS
16.		13:00	Visually inspect cooler for physical damage and record.	AKS
17.	13 JUNE	08:30	Conduct performance test per Para. 6.0 of this test plan	AKS
		2.6 X 10 ⁻¹⁰	Std. CC Helium/sec (record)	

Comments: _____

NVEOL CRYOGENIC COOLER LAP

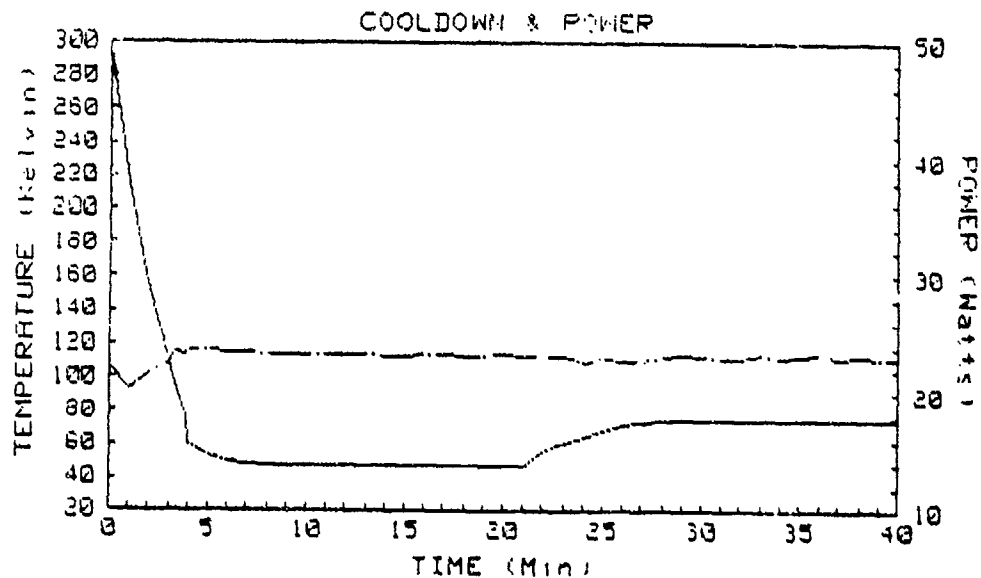
CRYOGENIC COOLER DATA

COOLER: RICOR / CT-4S 8011
VOLTAGE: 17.5
AMBIENT: 23 (C)

DATE: 13 JUNE 88 09:40
ENGR: HLO
DEWAR COMP: .335

TEST: PERFORMANCE TEST FOLLOWING TEMP SHOCK

TIME	POWER	CURRENT	KELVIN	LOAD
0.00	22.26	1.322	296.64	0.000
1.00	20.47	1.194	214.83	0.000
2.00	21.55	1.254	155.46	0.000
3.00	22.62	1.325	108.90	0.000
3.30	23.62	1.350	96.86	0.000
3.93	23.43	1.339	76.32	0.000
4.00	23.76	1.363	59.88	0.000
5.00	23.74	1.366	52.89	0.000
6.00	23.55	1.343	49.66	0.000
7.00	23.50	1.342	48.18	0.000
8.00	23.36	1.324	47.66	0.000
9.00	23.41	1.321	47.49	0.000
10.00	23.42	1.335	47.31	0.000
11.00	23.35	1.341	47.23	0.000
12.00	23.44	1.346	47.18	0.000
13.00	23.37	1.343	47.23	0.000
14.00	23.15	1.306	47.49	0.000
15.00	23.30	1.332	47.14	0.000
16.00	23.36	1.325	47.14	0.000
17.00	23.33	1.340	47.18	0.000
18.00	23.25	1.327	47.40	0.000
19.00	23.23	1.322	47.27	0.000
20.00	23.33	1.333	47.31	0.000
30.00	23.21	1.326	74.01	.351
40.00	23.11	1.301	74.82	.351



TEMPERATURE SHOCK TEST SUMMARY SHEET

Cooler S/N 013Date: 9 JUNE 88Test Tech. HLD

Project Eng. _____

Step	Date	Elapsed Time	Test requirement	Initial
1.0	<u>9 JUNE</u>	<u>10:50</u>	Install coolers into test chamber	<u>HLD</u>
2.0		<u>10:50</u>	Adjust chamber ambient to + 71C	<u>HLD</u>
3.0		<u>15:15</u>	verify cooler has soaked for four hours	<u>JKS</u>
4.0		<u>15:15</u>	Place cooler into test chamber that has been pre-cooled to -54C within 5 minutes from 71C	<u>JKS</u>
5.0		<u>19:15</u>	Verify cooler has soaked for four (4) hours at -54C	<u>HLD</u>
6.0		<u>19:15</u>	Place cooler into test chamber that has been pre-heated to 71C within 5 mins. of removing from -54C ambient.	<u>HLD</u>
7.0		<u>23:15</u>	Verify cooler has soaked for for hours at +71C	<u>HLD</u>
8.0		<u>23:15</u>	Place cooler into test chamber that has been pre-cooled to -54C within 5 mins. of removing from +71C ambient.	<u>HLD</u>
9.0	<u>10 JUNE</u>	<u>3:15</u>	Verify cooler has soaked for four hours at -54C	<u>HLD</u>
10.0		<u>3:15</u>	Place cooler into test chamber that has been pre-heated to +71C within 5 mins. of removing from -54C ambient.	<u>HLD</u>
11.0		<u>7:15</u>	Verify cooler has soaked for four hours at +71C	<u>JKS</u>
12.0		<u>7:15</u>	Place cooler into test chamber that has been pre-cooled to -54C within 5 mins. of removing from +71C ambient.	<u>JKS</u>

Test Sheet 5 (1 of 2)

Temperature Shock Test Summary Sheet (Continued)

Step	Date	Elapsed Time	Test Requirement	Initial
13.	10 JUNE	11:15	Verify cooler has soaked for four hours.	<u>AKS</u>
14.		11:15	Adjust test chamber ambient to +23C	<u>AKS</u>
15.		13:00	Verify test chamber Ambient is 23C	<u>AKS</u>
16.		13:00	Visually inspect cooler for physical damage and record.	<u>AKS</u>
17.	13 JUNE	07:15	Conduct performance test per Para. 6.0 of this test plan	<u>HLR</u>
		6.4 x 10 ⁻¹⁰	Std. CC Helium/sec (record)	

Comments: _____

NVEOL CRYOGENIC COOLER LAB

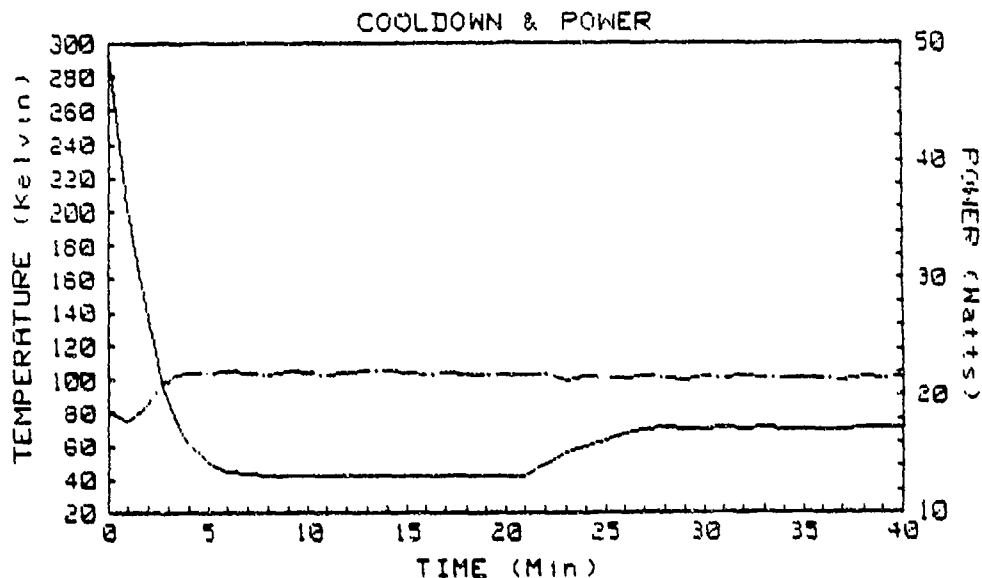
CRYOGENIC COOLER DATA

COOLER: RICOR / CT-45 013
VOLTAGE: 17.5
AMBIENT: 23 (C)

DATE: 13 JUNE 98 08:23
ENGR: HLD
DEWAR COMP: .335

TEST: PERFORMANCE TEST FOLLOWING TEMP SHOCK

TIME	POWER	CURRENT	KELVIN	LOAD
0.00	18.71	1.069	294.29	0.000
1.00	17.81	1.040	203.11	0.000
2.00	19.32	1.175	136.53	0.000
2.77	21.23	1.213	95.79	0.000
3.00	21.26	1.239	87.60	0.000
3.30	21.73	1.242	77.39	0.000
4.00	22.00	1.261	61.10	0.000
5.00	22.05	1.233	49.49	0.000
6.00	22.23	1.266	44.48	0.000
7.00	21.90	1.237	43.13	0.000
8.00	21.93	1.225	42.43	0.000
9.00	22.11	1.260	42.04	0.000
10.00	21.94	1.250	41.74	0.000
11.00	21.86	1.233	41.74	0.000
12.00	21.97	1.248	41.82	0.000
13.00	22.12	1.266	41.74	0.000
14.00	22.08	1.232	41.60	0.000
15.00	22.04	1.253	41.69	0.000
16.00	21.79	1.236	41.78	0.000
17.00	22.05	1.262	41.87	0.000
18.00	21.89	1.255	41.95	0.000
19.00	21.85	1.246	42.04	0.000
20.00	21.84	1.257	41.78	0.000
30.00	21.70	1.276	69.09	.351
40.00	21.57	1.225	70.20	.351



HIGH TEMPERATURE TEST SUMMARY SHEET

Cooler S/N 8011Date of Test 14-16 JUNE 88Testrr Tech HLD

Project Eng. _____

Step	Date	Elapsed Time (Hr.-Min)	Test Requirement
1.0	<u>14 JUNE</u>	<u>08:50</u>	Install the cooler into the test chamber instrumented per Para. 6.3
2.0		<u>09:05</u>	Adjust chamber ambient to +71C
3.0	<u>16 JUNE</u>	<u>09:07</u>	Verify cooler has soaked for 48 hours at +71C
4.0		<u>✓</u>	Operate the coolers in accordance with Para. 6.0 and record results.
5.0		<u>✓</u>	Lower test chamber to standard room ambient (non-operating)
6.0		<u>✓</u>	Visually inspect coolers for physical damage and record abnormal findings.
7.0	<u>16 JUNE</u>	<u>✓</u>	Conduct performance test at 23C per Para. 6.0. and record results.

16 JUNE 8.0 X 10⁻⁹ Std. CC Helium/Sec. (Record)

Comments: MOTOR HAS REMOVED

NVEOL CRYOGENIC COOLER LAB

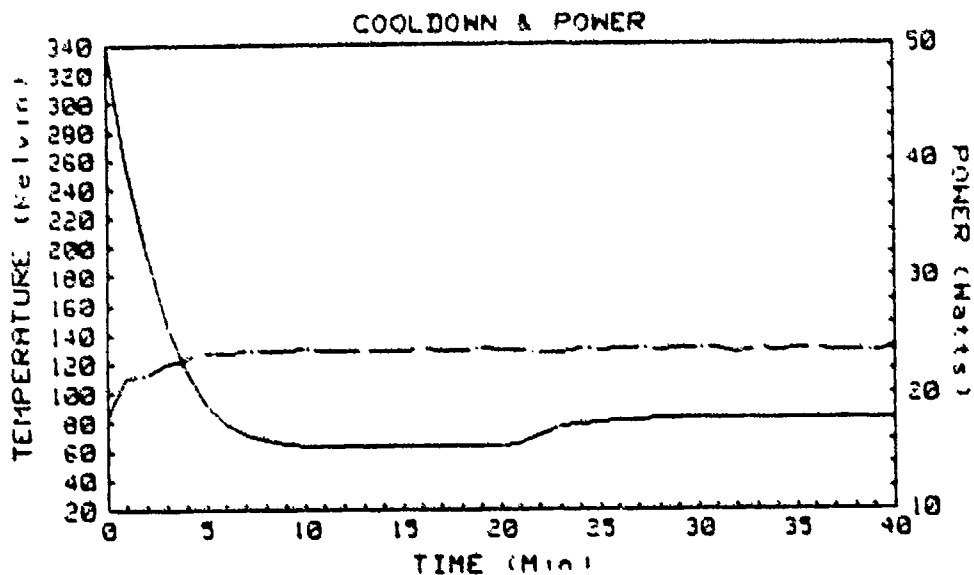
CRYOGENIC COOLER DATA

COOLER: RIGOR / CT-45 8011
VOLTAGE: 17.5 -
AMBIENT: 71 (C)

DATE: 16 JUNE 88 10:15
ENGR: HLD
DEWAR COMP: .335

TEST: PERFORMANCE TEST FOLLOWING 48 HOUR SOAK

TIME	POWER	CURRENT	KELVIN	LOAD
0.00	18.19	1.040	342.94	0.000
1.00	21.26	1.239	256.54	0.000
2.00	21.51	1.249	195.58	0.000
3.00	22.53	1.298	148.78	0.000
4.00	22.93	1.327	114.49	0.000
4.58	23.49	1.342	99.87	0.000
5.00	23.33	1.324	92.48	0.000
6.00	23.39	1.328	79.50	0.000
6.13	23.33	1.333	78.04	0.000
7.00	23.54	1.358	71.54	0.000
8.00	23.65	1.360	67.76	0.000
9.00	23.54	1.361	65.40	0.000
10.00	23.66	1.345	64.38	0.000
11.00	23.49	1.326	64.05	0.000
12.00	23.61	1.355	63.80	0.000
13.00	23.51	1.336	63.76	0.000
14.00	23.49	1.341	63.88	0.000
15.00	23.50	1.341	63.72	0.000
16.00	23.70	1.374	64.01	0.000
17.00	23.60	1.341	64.01	0.000
18.00	23.55	1.335	64.01	0.000
19.00	23.72	1.363	64.17	0.000
20.00	23.60	1.329	64.17	0.000
30.00	23.67	1.350	83.00	.201
40.00	23.83	1.366	83.46	.201



NVEOL CRYOGENIC COOLER LAB

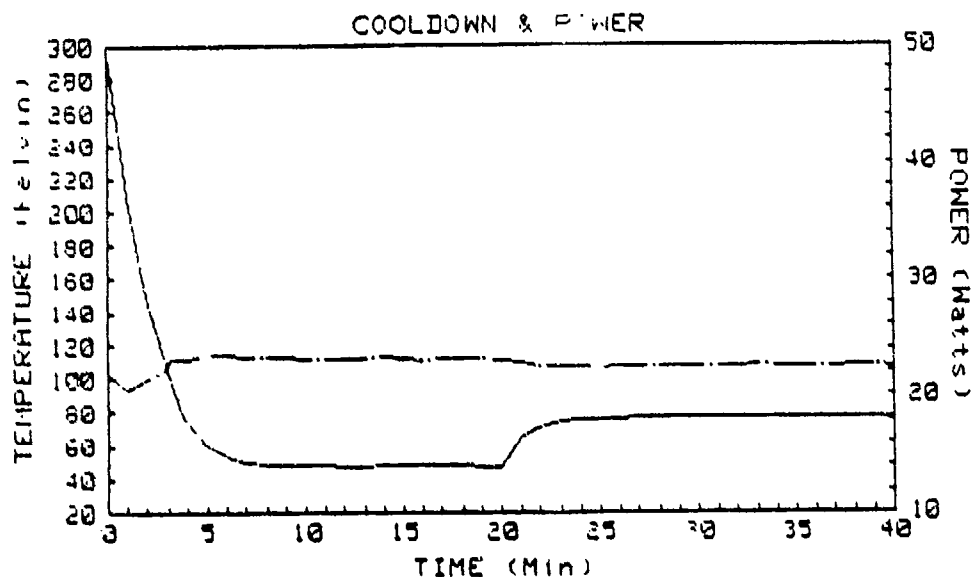
CRYOGENIC COOLER DATA

COOLER: RICOR / CT-45 8011
VOLTAGE: 17.5
AMBIENT: 23 (C)

DATE: 17 JUNE 98 08:56
ENGR: HLD
DEWAR COMP: .335

TEST: ROOM AMBIENT PERFORMANCE TEST FOLLOWING HIGH TEMP TEST

TIME	POWER	CURRENT	KELVIN	LOAD
0.00	21.83	1.247	295.38	0.000
1.00	20.38	1.171	209.28	0.000
2.00	21.22	1.248	148.99	0.000
3.00	22.40	1.323	103.91	0.000
3.10	23.10	1.320	99.72	0.000
3.77	23.01	1.315	79.35	0.000
4.00	23.11	1.333	74.20	0.000
5.00	23.39	1.338	58.91	0.000
6.00	23.34	1.324	52.77	0.000
7.00	23.22	1.329	49.84	0.000
8.00	23.13	1.320	48.62	0.000
9.00	23.15	1.325	48.18	0.000
10.00	23.09	1.312	47.97	0.000
11.00	22.98	1.311	47.79	0.000
12.00	23.05	1.323	47.53	0.000
13.00	23.10	1.324	47.70	0.000
14.00	23.16	1.321	47.79	0.000
15.00	23.02	1.321	47.97	0.000
16.00	22.91	1.311	48.14	0.000
17.00	23.00	1.311	48.05	0.000
18.00	22.97	1.312	48.05	0.000
19.00	22.98	1.307	47.75	0.000
20.00	22.92	1.311	47.75	0.000
30.00	22.37	1.284	76.58	.351
40.00	22.42	1.285	76.66	.351



HIGH TEMPERATURE TEST SUMMARY SHEET

Cooler S/N 013Date of Test 14-16 JUNE 88Testrr Tech HLD

Project Eng. _____

Step	Date	Elapsed Time (Hr.-Min)	Test Requirement
1.0	<u>14 JUNE</u>	<u>08:50</u>	Install the cooler into the test chamber instrumented per Para. 6.3
2.0		<u>09:05</u>	Adjust chamber ambient to +71C
3.0	<u>16 JUNE</u>	<u>10:21</u>	Verify cooler has soaked for 48 hours at +71C
4.0		<u>✓</u>	Operate the coolers in accordance with Para. 6.0 and record results.
5.0		<u>✓</u>	Lower test chamber to standard room ambient (non-operating)
6.0		<u>✓</u>	Visually inspect coolers for physical damage and record abnormal findings.
7.0		<u> </u>	Conduct performance test at 23C per Para. 6.0. and record results.

17 JUNE 7.0 X 10⁻⁹ Std. CC Helium/Sec. (Record)

Comments: _____

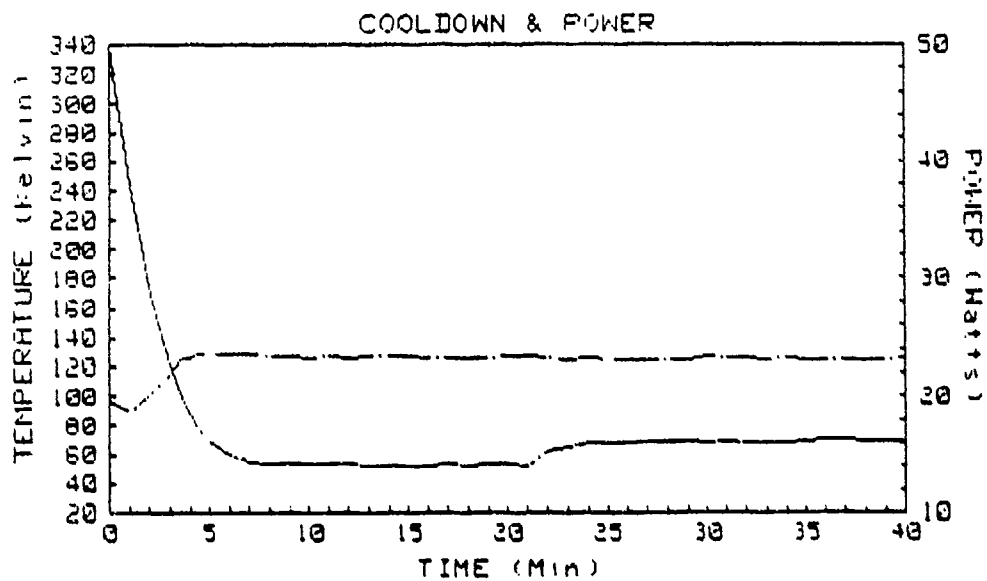
CRYOGENIC COOLER DATA

COOLER: RICOR / CT-45 013
 VOLTAGE: 17.5
 AMBIENT: 71 (C)

DATE: 15 JUNE 88 11:23
 ENGR: HLD
 DEWAR COMP: .143

TEST: PERFORMANCE TEST FOLLOWING 48 HOUR SOAK

TIME	POWER	CURRENT	KELVIN	LOAD
0.00	19.52	1.116	344.26	0.000
1.00	18.60	1.113	242.84	0.000
2.00	20.11	1.200	173.74	0.000
3.00	21.86	1.263	121.69	0.000
3.60	23.29	1.331	98.73	0.000
4.00	23.15	1.334	88.08	0.000
4.43	23.62	1.350	78.04	0.000
5.00	23.62	1.343	69.82	0.000
6.00	23.53	1.335	59.64	0.000
7.00	23.52	1.341	55.35	0.000
8.00	23.45	1.363	54.00	0.000
9.00	23.40	1.325	53.38	0.000
10.00	23.30	1.323	53.92	0.000
11.00	23.31	1.336	53.38	0.000
12.00	23.27	1.312	53.34	0.000
13.00	23.37	1.315	53.05	0.000
14.00	23.34	1.338	52.73	0.000
15.00	23.41	1.333	52.64	0.000
16.00	23.30	1.329	52.81	0.000
17.00	23.27	1.337	53.71	0.000
18.00	23.30	1.334	52.10	0.000
19.00	23.26	1.317	53.50	0.000
20.00	23.34	1.337	53.14	0.000
30.00	23.40	1.337	68.52	.201
40.00	23.25	1.332	69.13	.201



NVEOL CRYOGENIC COOLER LAB

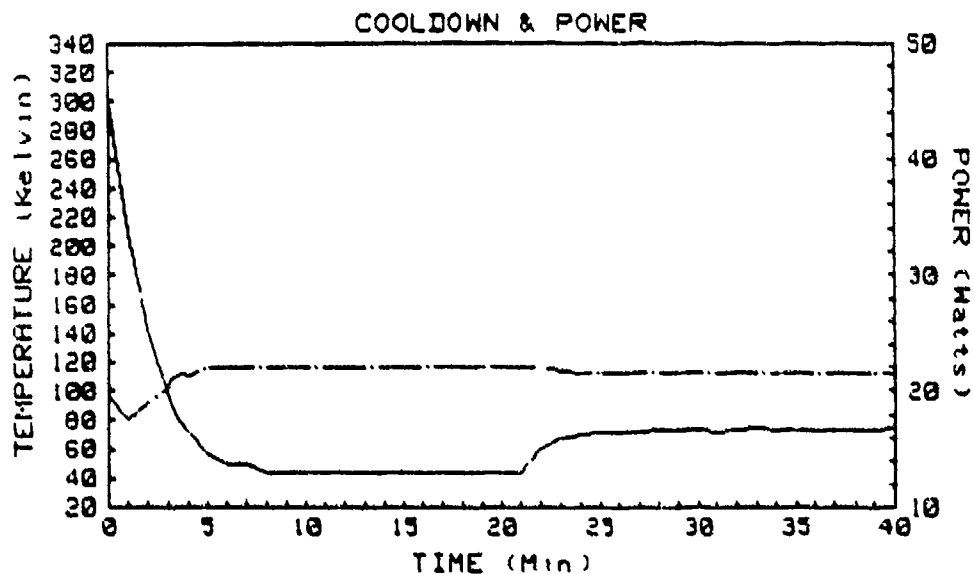
CRYOGENIC COOLER DATA

COOLER: RICOR / CRYOTEK 013
VOLTAGE: 17.5
AMBIENT: 23 (C)

DATE: 16 JUNE 1988 19:34
ENGR: RNS
DEWAR COMP: .143

TEST: BASELINE AFTER HIGH TEMP

TIME	POWER	CURRENT	KELVIN	LOAD
0.00	19.50	1.114	300.60	0.000
1.00	17.61	1.044	209.14	0.000
2.00	18.95	1.124	142.13	0.000
3.00	20.30	1.189	97.44	0.000
3.10	20.98	1.199	93.92	0.000
3.65	21.42	1.224	78.66	0.000
4.00	21.23	1.227	71.85	0.000
5.00	22.06	1.255	56.66	0.000
6.00	22.07	1.257	49.01	0.000
7.00	21.90	1.247	50.10	0.000
8.00	22.04	1.268	44.61	0.000
9.00	22.01	1.256	44.13	0.000
10.00	21.95	1.246	43.87	0.000
11.00	22.05	1.259	43.91	0.000
12.00	21.99	1.250	43.83	0.000
13.00	21.94	1.247	43.78	0.000
14.00	22.06	1.257	43.91	0.000
15.00	21.99	1.267	43.91	0.000
16.00	22.04	1.272	43.87	0.000
17.00	22.04	1.264	43.78	0.000
18.00	22.00	1.260	43.87	0.000
19.00	22.02	1.259	44.00	0.000
20.00	22.02	1.253	44.00	0.000
30.00	21.48	1.220	73.36	.351
40.00	21.49	1.226	75.13	.351



LOW TEMPERATURE TEST SUMMARY SHEET

Cooler S/N 8011Date 21-22 JUNE 88Test tech HLD

Project Eng. _____

Step	Date	Elapsed Time (Hour/Min.)	Test Requirement
1.0	<u>21 JUNE</u>	<u>06:05</u>	Install cooler into test chamber as per Para. 6.3.
2.0		<u>06:55 @ -57C</u>	Adjust test chamber to -57C
3.0	<u>22 JUNE</u>	<u>06:55</u>	Verify cooler has soaked for <u>24</u> hours at -57C
4.0		<u>07:50</u>	Raise the temperature to -40 and allow coolers to stabilize.
5.0		<u>✓</u>	Operate coolers in accordance to para. 6.0 and record results.
6.0		<u>✓</u>	Raise test chamber to standard room ambient +23C (non-operating)
7.0		<u>✓</u>	Visually inspect coolers for any physical damage and record.
8.0		<u>✓</u>	Conduct Performance test at +23C and record

2×10^{-9} Std. CC Helium/Sec. (record)

Comments: _____

Test Sheet 7

NVEOL CRYOGENIC COOLER LAB

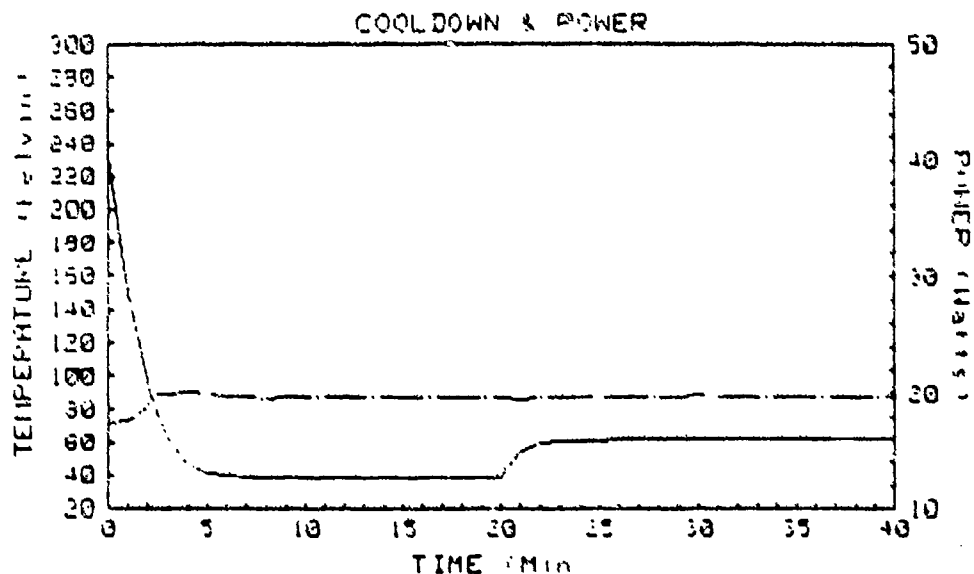
CRYOGENIC COOLER DATA

COOLER: RIGOR / CRYOTEK 8011
 VOLTAGE: 17.5
 AMBIENT: -40 (C)

DATE: 22 JUNE 1988 09:48
 ENGR: HLD
 DEWAR COMP: .335

TEST: PERFORMANCE TEST FOLLOWING 24 HOUR SOAK

TIME	POWER	CURRENT	KELVIN	LOAD
0.00	17.47	.998	232.97	0.000
1.00	17.63	1.033	149.92	3.000
2.00	18.83	1.121	96.67	0.000
2.10	19.50	1.114	91.90	0.000
2.43	19.81	1.132	78.62	0.000
3.00	19.78	1.145	62.12	0.000
4.00	20.00	1.136	46.44	0.000
5.00	19.78	1.119	41.13	0.000
6.00	19.73	1.129	39.47	0.000
7.00	19.61	1.119	38.67	0.000
8.00	19.58	1.121	38.37	0.000
9.00	19.70	1.121	38.22	0.000
10.00	19.69	1.130	38.19	0.000
11.00	19.60	1.120	38.14	0.000
12.00	19.76	1.130	38.14	0.000
13.00	19.75	1.129	38.14	0.000
14.00	19.69	1.125	38.14	0.000
15.00	19.78	1.125	38.14	0.000
16.00	19.74	1.128	38.14	0.000
17.00	19.67	1.135	38.14	0.000
18.00	19.76	1.128	38.18	0.000
19.00	19.71	1.133	38.18	0.000
20.00	19.76	1.126	38.19	0.000
30.00	19.79	1.131	61.63	.348
40.00	19.65	1.114	62.12	.350



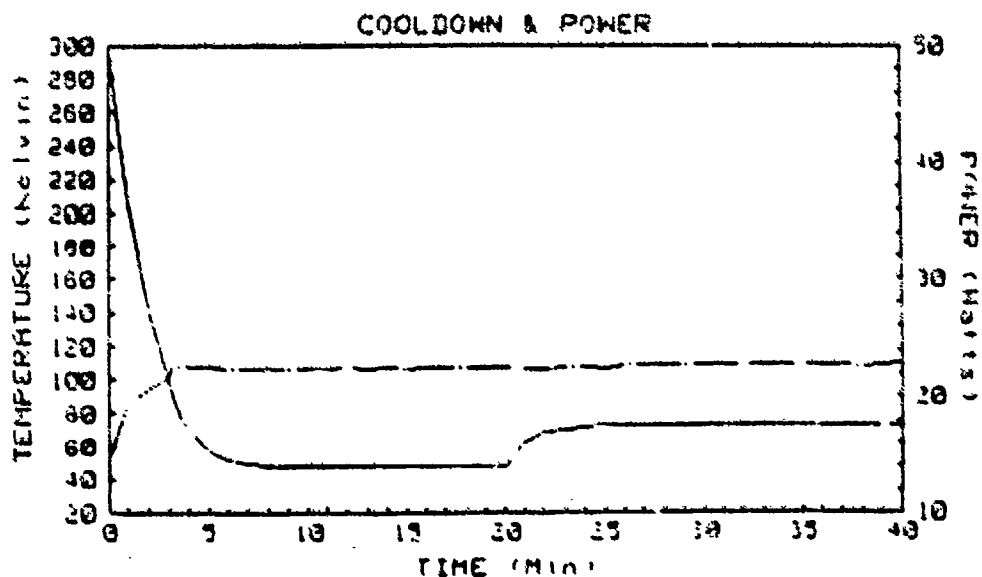
CRYOGENIC COOLER DATA

COOLER: RICOR / CRYOTEK 8011
VOLTAGE: 17.5
AMBIENT: 23 (C)

DATE: 22 JUNE 1988 13:39
ENGR: RNS
DEWAR COMP: .335

TEST: POST LOW TEMP BASELINE

TIME	POWER	CURRENT	KELVIN	LOAD
0.00	14.74	.842	296.99	0.000
1.00	19.36	1.136	205.80	0.000
2.00	20.51	1.199	142.99	0.000
3.00	21.68	1.268	97.59	0.000
3.10	22.42	1.281	93.77	0.000
3.67	22.45	1.283	77.35	0.000
4.00	22.45	1.288	70.55	0.000
5.00	22.58	1.287	57.28	0.000
6.00	22.41	1.284	51.58	0.000
7.00	22.32	1.278	49.36	0.000
8.00	22.39	1.280	48.27	0.000
9.00	22.35	1.274	47.92	0.000
10.00	22.39	1.273	47.79	0.000
11.00	22.35	1.283	47.79	0.000
12.00	22.45	1.280	47.84	0.000
13.00	22.40	1.283	47.92	0.000
14.00	22.45	1.273	47.97	0.000
15.00	22.41	1.290	48.05	0.000
16.00	22.51	1.281	48.10	0.000
17.00	22.56	1.289	48.14	0.000
18.00	22.58	1.295	48.18	0.000
19.00	22.53	1.291	48.23	0.000
20.00	22.49	1.266	48.18	0.000
30.00	22.62	1.299	73.24	.350
40.00	22.81	1.298	73.24	.350



LOW TEMPERATURE TEST SUMMARY SHEET

Cooler S/N 013Date 17-18 JUNE 88Test tech HLD

Project Eng. _____

Step	Date	Elapsed Time (Hour/Min.)	Test Requirement
1.0	<u>17 JUNE</u>	<u>09:30</u>	Install cooler into test chamber as per Para. 6.3.
2.0		<u>10:20 @ -57</u>	Adjust test chamber to -57C
3.0	<u>18 JUNE</u>	<u>10:20</u>	Verify cooler has soaked for 48 <u>24</u> hours at -57C
4.0		<u>11:15</u>	Raise the temperature to -40 and allow coolers to stabilize.
5.0		<u>✓</u>	Operate coolers in accordance to para. 6.0 and record results.
6.0		<u>✓</u>	Raise test chamber to standard room ambient +23C (non-operating)
7.0		<u>✓</u>	Visually inspect coolers for any physical damage and record.
8.0		<u>✓</u>	Conduct Performance test at +23C and record

 7.9×10^{-9} Std. CC Helium/Sec. (record)
 Comments: _____

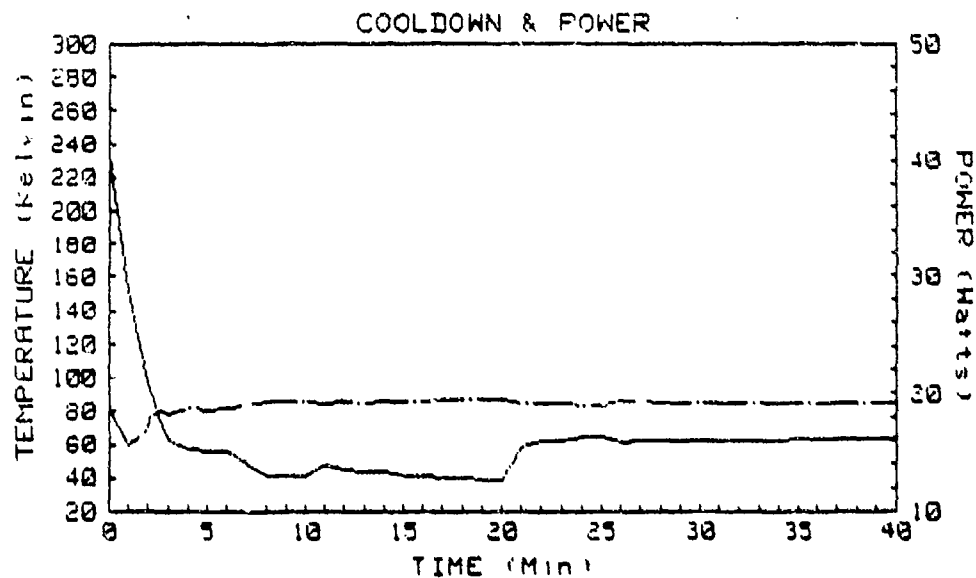
CRYOGENIC COOLER DATA

COOLER: RICOR / CRYOTEK 013
 VOLTAGE: 17.5
 AMBIENT: -40 (C)

DATE: 18 JUNE 1988 12:22
 ENGR: RNS
 DEWAR COMP: .143

TEST: COLD TEMP BASELINE

TIME	POWER	CURRENT	KELVIN	LOAD
0.00	18.77	1.073	233.00	0.000
1.00	15.65	.945	151.49	0.000
2.00	17.02	.993	97.00	0.000
2.10	18.01	1.029	92.70	0.000
2.53	18.63	1.065	76.58	0.000
3.00	18.22	1.072	62.41	0.000
4.00	18.88	1.084	57.03	0.000
5.00	18.56	1.065	55.72	0.000
6.00	18.75	1.072	55.43	0.000
7.00	18.99	1.106	47.97	0.000
8.00	19.41	1.108	40.82	0.000
9.00	19.29	1.084	41.26	0.000
10.00	19.28	1.083	41.13	0.000
11.00	19.21	1.094	46.88	0.000
12.00	19.30	1.101	44.92	0.000
13.00	19.18	1.090	43.09	0.000
14.00	19.28	1.108	43.48	0.000
15.00	19.29	1.099	41.08	0.000
16.00	19.37	1.116	40.95	0.000
17.00	19.43	1.116	39.54	0.000
18.00	19.45	1.110	39.13	0.000
19.00	19.50	1.107	39.01	0.000
20.00	19.51	1.110	39.01	0.000
30.00	19.17	1.090	61.79	.351
40.00	19.12	1.097	63.43	.351



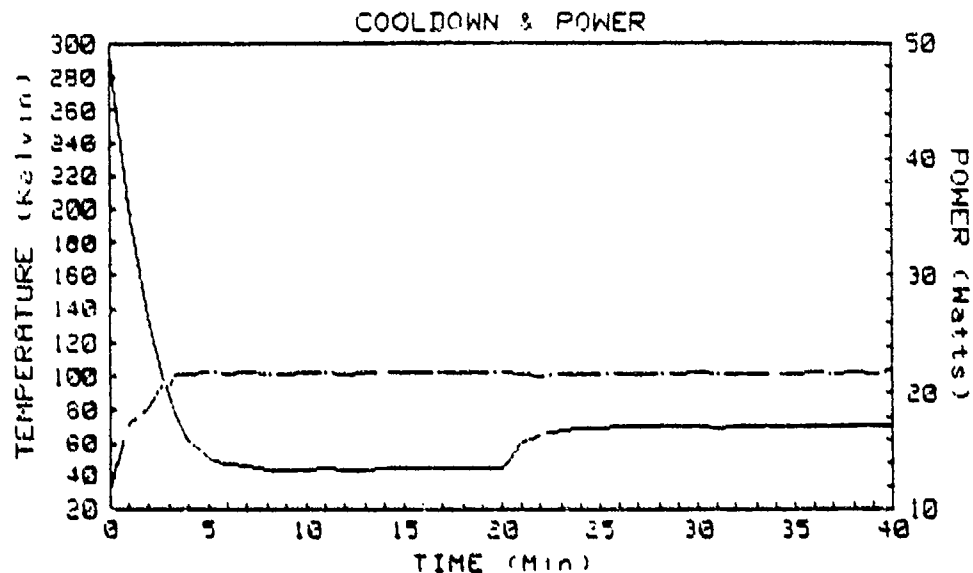
CRYOGENIC COOLER DATA

COOLER: RICOR / CT-45 013
VOLTAGE: 17.5
AMBIENT: 23 (C)

DATE: 20 JUNE 88 07:33
ENGR: HLD
DEWAR COMP: .143

TEST: ROOM AMBIENT PERFORMANCE TEST FOLLOWING COLD TEMP TEST

TIME	POWER	CURRENT	KELVIN	LOAD
0.00	11.77	.673	295.62	0.000
1.00	17.40	1.019	200.78	0.000
2.00	18.80	1.112	135.16	0.000
2.77	20.85	1.191	97.41	0.000
3.00	20.46	1.216	89.03	0.000
3.32	21.59	1.234	77.46	0.000
4.00	21.59	1.230	62.33	0.000
5.00	21.75	1.244	50.71	0.000
6.00	21.72	1.247	47.01	0.000
7.00	21.73	1.241	45.48	0.000
8.00	21.68	1.233	44.04	0.000
9.00	21.67	1.249	43.74	0.000
10.00	21.72	1.248	43.96	0.000
11.00	21.72	1.240	44.18	0.000
12.00	21.72	1.241	43.74	0.000
13.00	21.74	1.252	43.78	0.000
14.00	21.74	1.242	44.44	0.000
15.00	21.73	1.234	44.31	0.000
16.00	21.74	1.245	44.26	0.000
17.00	21.81	1.242	44.44	0.000
18.00	21.77	1.238	44.31	0.000
19.00	21.78	1.246	44.09	0.000
20.00	21.83	1.246	44.44	0.000
30.00	21.73	1.250	70.01	.351
40.00	21.74	1.238	70.13	.351



MECHANICAL SHOCK—S/N 8011

MECHANICAL SHOCK TEST SUMMARY SHEETCooler S/N 8011Date 20 JULY 88Test Tech HLD

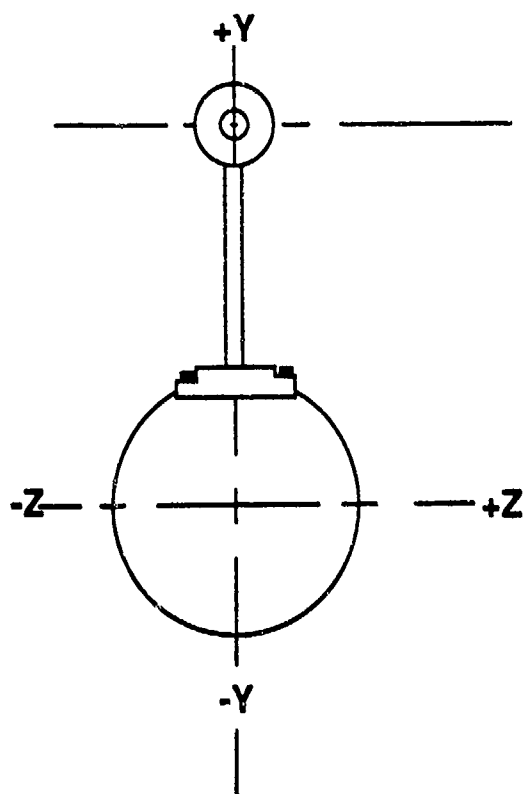
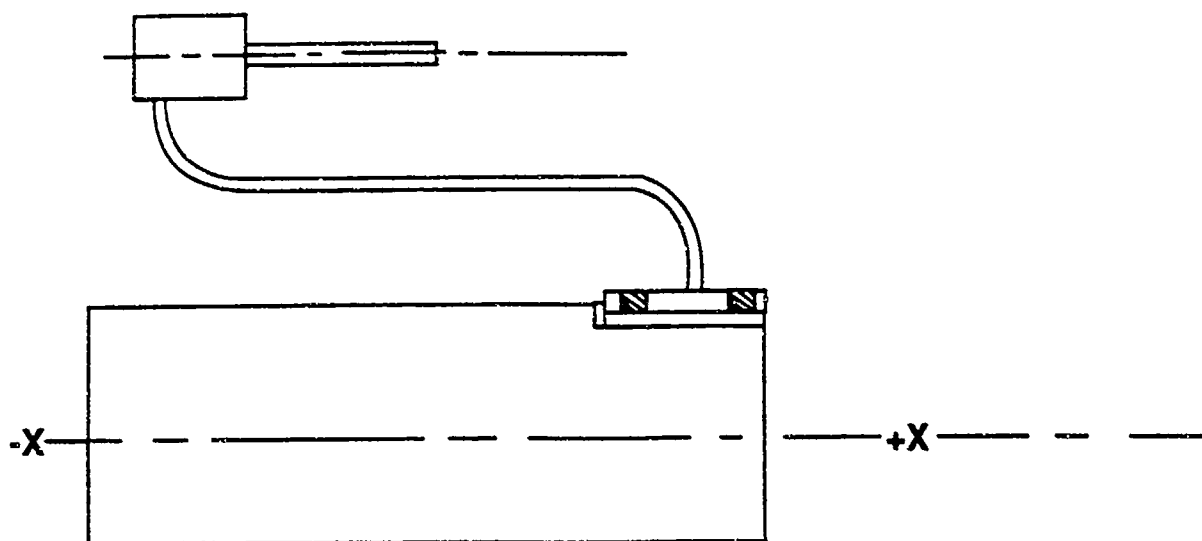
Project Engineer _____

Step	Requirement	Initial
1.0	Verify Shock Machine is calibrated	<u>i.i.</u>
2.0	Install instrumented cooler with power leads only onto the shock table. (X axis)	<u>✓</u>
3.0	Energize cooler and operate with no thermal load or instrumentation on the coldfinger.	<u>✓</u>
4.0	Apply two shocks in the positive X axis	<u>✓</u>
5.0	Apply two shocks in the minus X axis	<u>✓</u>
6.0	Change the cooler into the Y axis	<u>✓</u>
7.0	Apply two shocks in the positive Y axis	<u>✓</u>
8.0	Apply two shocks in the minus Y axis	<u>✓</u>
9.0	Change cooler into the Z axis	<u>✓</u>
10.0	Apply two shocks in the positive Z axis	<u>✓</u>
11.0	Apply two shocks in the minus Z axis	<u>✓</u>
12.0	De-energize cooler and inspect for physical damage. Record results.	<u>✓</u>
17.0	Conduct performance test per para 6.0	<u>✓</u>
	<u>7.5×10^{-9}</u> Std. cc helium/sec	

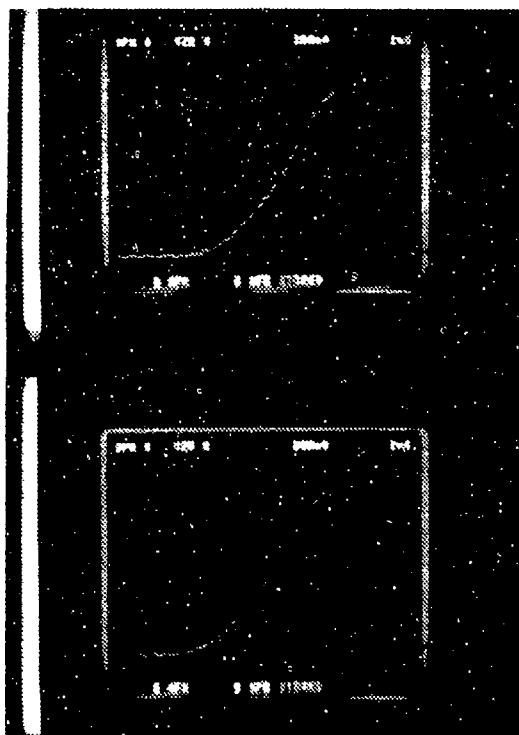
Comments _____

Test Sheet B

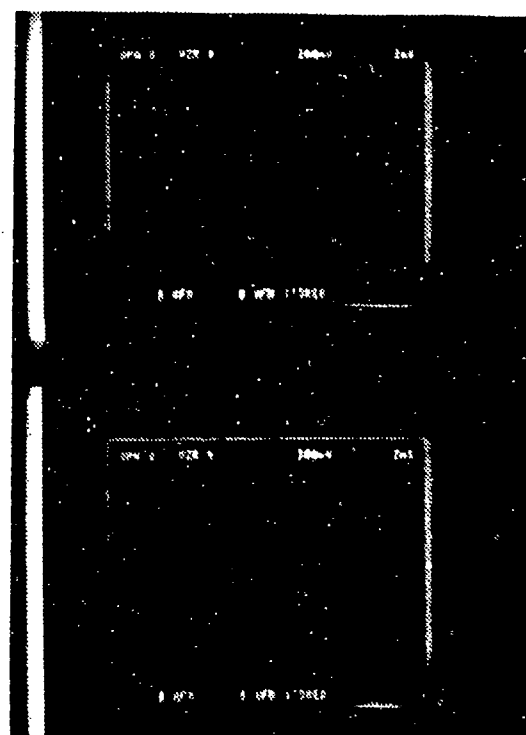
MECHANICAL VIBRATION ORIENTATION



RICOR/CRYO-TEK
S/N 8011

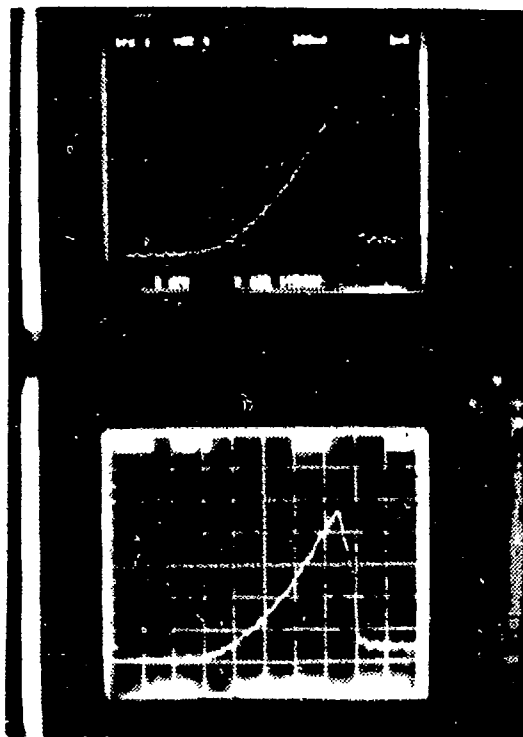


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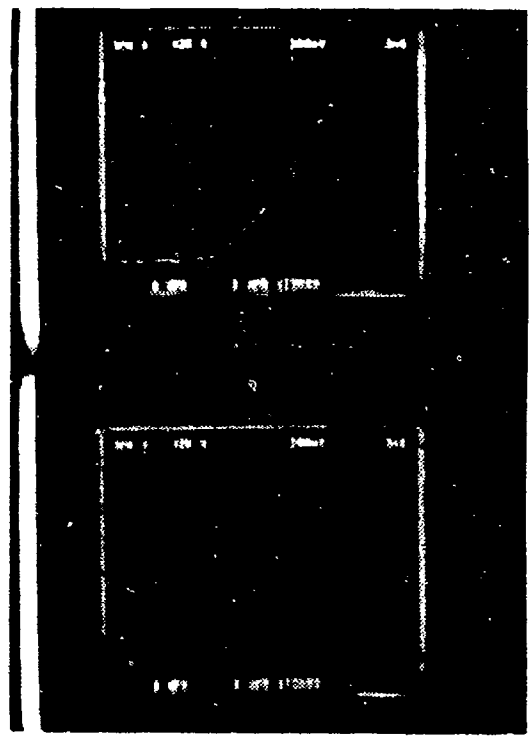


- X AXIS

RICOR/CRYO-TEK
S/N 8011

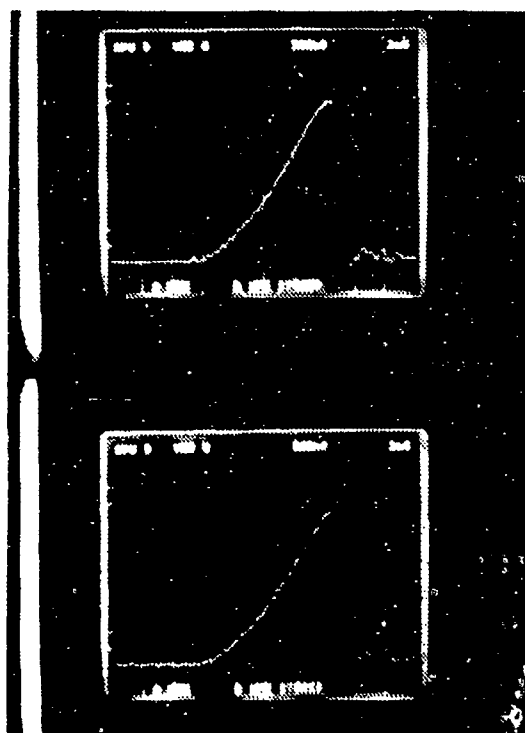


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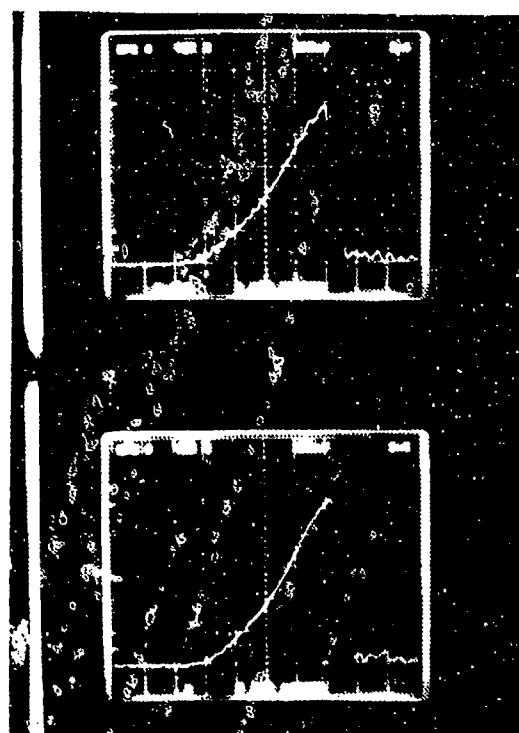


-Y AXIS

RICOR/CRYO-TEK
S/N 8011



+Z AXIS



- Z AXIS

CRYOGENIC COOLER DATA

COOLER: RICOR / CT-45 8011

DATE: 21 JULY 88 11:19

VOLTAGE: 17.5

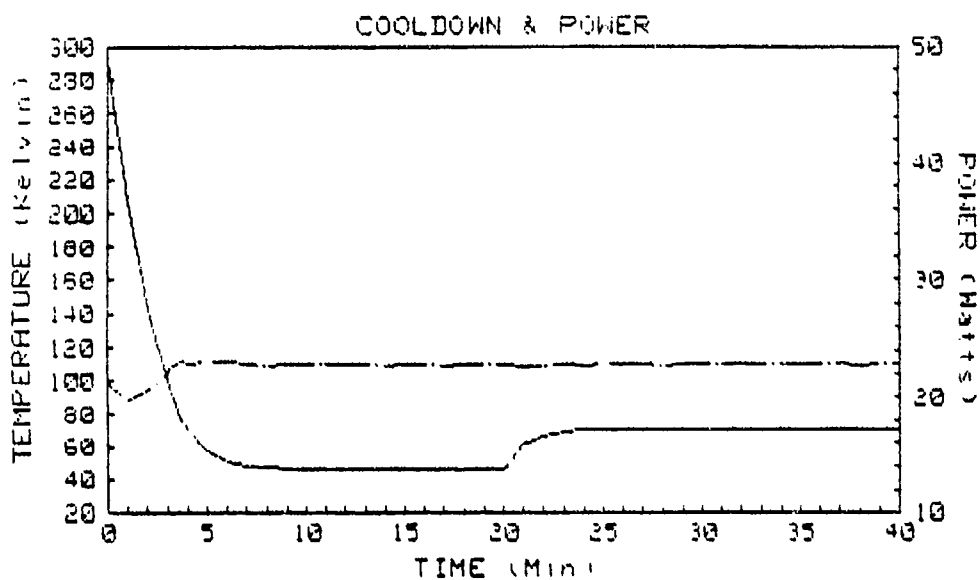
ENGR: HLD

AMBIENT: 23 (C)

DEWAR COMP: .335

TEST: PERFORMANCE TEST FOLLOWING MECHANICAL SHOCK

TIME	POWER	CURRENT	KELVIN	LOAD
0.00	21.19	1.211	293.16	0.000
1.00	19.68	1.148	207.59	0.000
2.00	20.66	1.217	147.61	0.000
3.00	21.95	1.299	100.09	0.000
3.10	22.56	1.299	95.87	0.000
3.67	23.07	1.318	78.07	0.000
4.00	22.81	1.307	70.69	0.000
5.00	23.10	1.317	56.55	0.000
6.00	23.00	1.305	50.57	0.000
7.00	22.89	1.306	48.08	0.000
8.00	22.70	1.300	46.99	0.000
9.00	22.85	1.310	46.51	0.000
10.00	22.81	1.301	46.25	0.000
11.00	22.83	1.304	46.17	0.000
12.00	22.81	1.305	46.17	0.000
13.00	22.79	1.304	46.21	0.000
14.00	22.76	1.302	46.25	0.000
15.00	22.85	1.303	46.25	0.000
16.00	22.78	1.304	46.30	0.000
17.00	22.64	1.298	46.17	0.000
18.00	22.80	1.300	46.34	0.000
19.00	22.83	1.301	46.34	0.000
20.00	22.84	1.309	46.34	0.000
30.00	22.81	1.296	71.00	.351
40.00	22.80	1.308	71.00	.351



MECHANICAL SHOCK—S/N 013

MECHANICAL SHOCK TEST SUMMARY SHEETCooler S/N 013Date 20 July 88Test Tech HLD

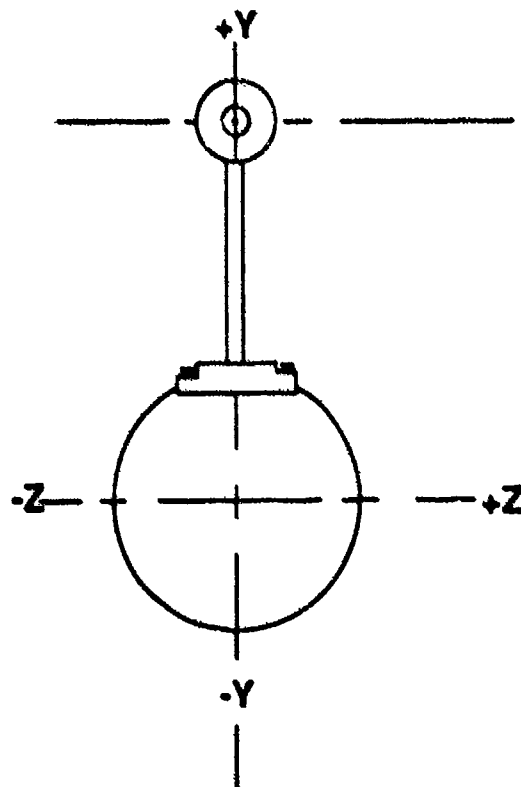
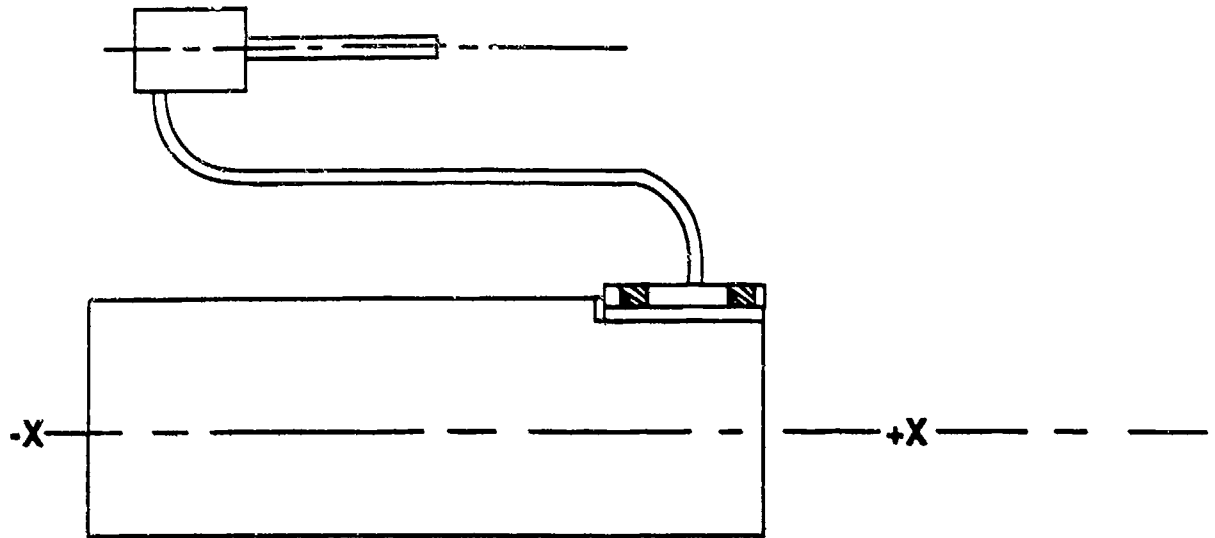
Project Engineer _____

Step	Requirement	Initial
1.0	Verify Shock Machine is calibrated	<u>HLD</u>
2.0	Install instrumented cooler with power leads only onto the shock table. (X axis)	<u>✓</u>
3.0	Energize cooler and operate with no thermal load or instrumentation on the coldfinger.	<u>✓</u>
4.0	Apply two shocks in the positive X axis	<u>✓</u>
5.0	Apply two shocks in the minus X axis	<u>✓</u>
6.0	Change the cooler into the Y axis	<u>✓</u>
7.0	Apply two shocks in the positive Y axis	<u>✓</u>
8.0	Apply two shocks in the minus Y axis	<u>✓</u>
9.0	Change cooler into the Z axis	<u>✓</u>
10.0	Apply two shocks in the positive Z axis	<u>✓</u>
11.0	Apply two shocks in the minus Z axis	<u>✓</u>
12.0	De-energize cooler and inspect for physical damage. Record results.	<u>✓</u>
13.0	Conduct performance test per para 6.0	<u>✓</u>
	<u>5.4×10^{-9}</u> Std. cc helium/sec	

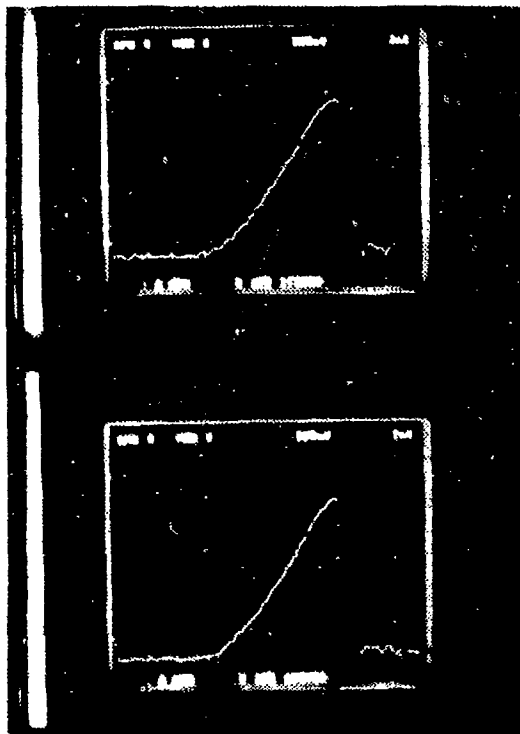
Comments _____

Test Sheet B

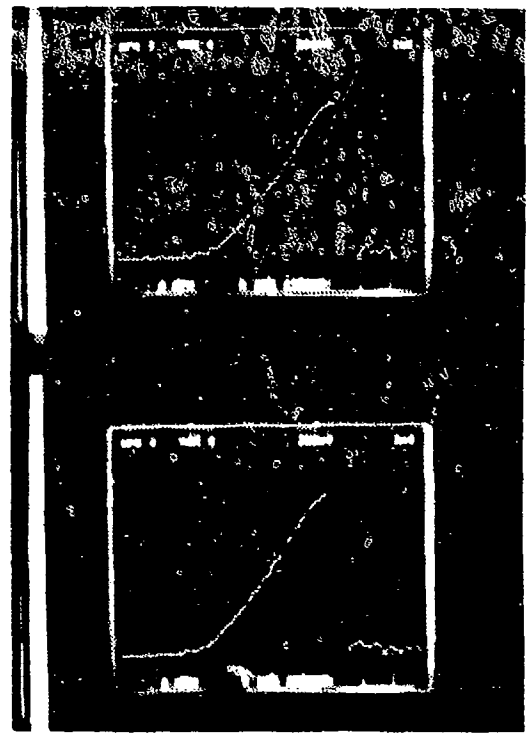
MECHANICAL VIBRATION ORIENTATION



RICOR/CRYO-TEK
S/N 013

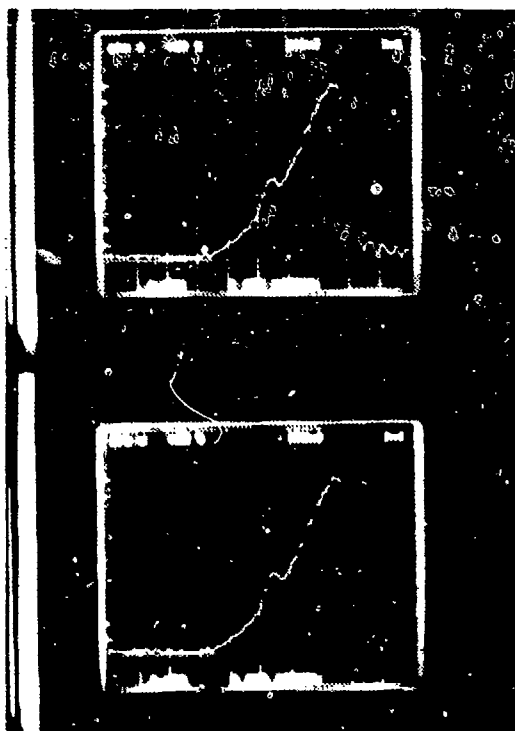


+X AXIS

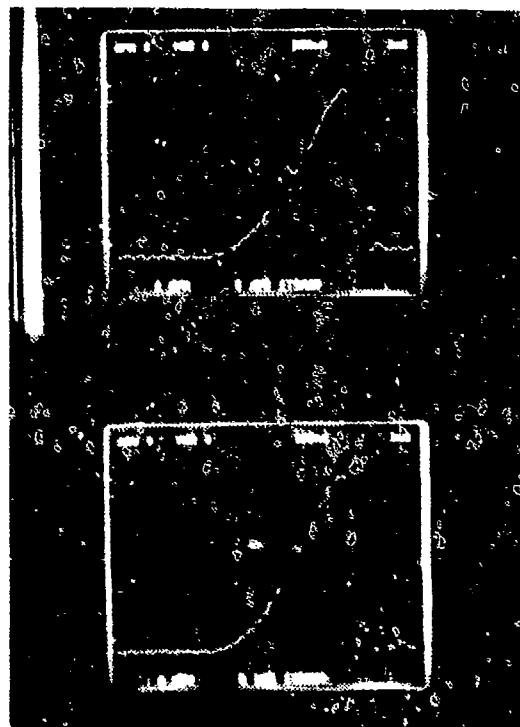


- X AXIS

RICOR/CRYO-TEK
S/N 013



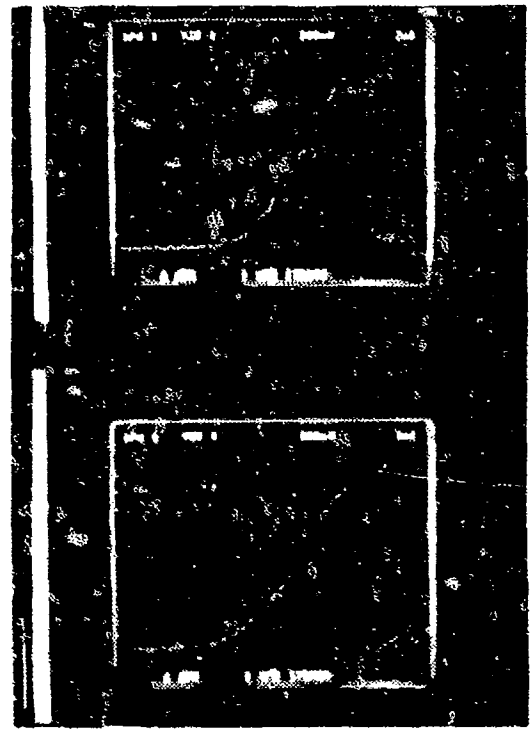
+Y AXIS



- Y AXIS



+Z AXIS



- Z AXIS

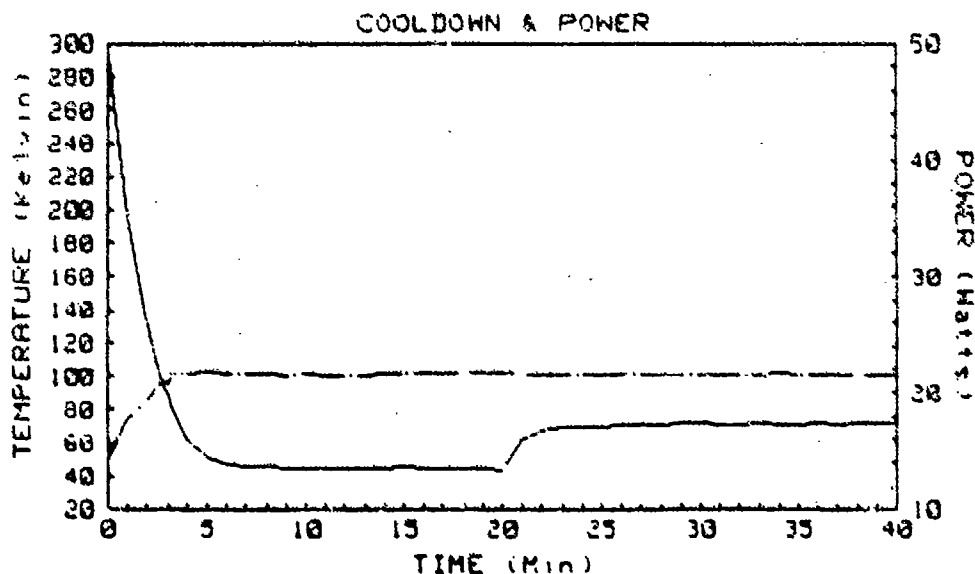
CRYOGENIC COOLER DATA

COOLER: RICOR / CT-45 013
VOLTAGE: 17.5
AMBIENT: 23 (C)

DATE: 21 JULY 89 08:35
ENGR: HLD
DEWAR COMP: .143

TEST: PERFORMANCE TEST FOLLOWING MECHANICAL SHOCK

TIME	POWER	CURRENT	KELVIN	LOAD
0.00	14.29	.817	272.30	0.000
1.00	17.76	1.052	196.53	0.000
2.00	19.08	1.132	134.74	0.000
2.77	21.04	1.202	96.41	0.000
3.00	20.68	1.225	88.51	0.000
3.22	21.60	1.234	80.07	0.000
4.00	21.62	1.250	62.51	0.000
5.00	21.78	1.245	50.77	0.000
6.00	21.65	1.235	47.72	0.000
7.00	21.64	1.250	45.54	0.000
8.00	21.60	1.235	45.76	0.000
9.00	21.52	1.220	45.02	0.000
10.00	21.54	1.234	44.10	0.000
11.00	21.52	1.237	44.93	0.000
12.00	21.50	1.227	44.27	0.000
13.00	21.52	1.231	44.84	0.000
14.00	21.58	1.217	44.54	0.000
15.00	21.59	1.224	45.41	0.000
16.00	21.64	1.229	44.45	0.000
17.00	21.67	1.241	44.54	0.000
18.00	21.62	1.234	44.19	0.000
19.00	21.54	1.224	44.06	0.000
20.00	21.55	1.232	43.97	0.000
30.00	21.51	1.230	71.38	.352
40.00	21.48	1.224	71.65	.352



ACOUSTIC NOISE
Noise Unlimited Data

Test Report No. 4773.01

No. of Pages 9

Report of Test on

RICOR 1/4 Watt Split
P/N K516 CT-45
S/N 013
for
Cryo-Tek Corp.
Woodbridge, Virginia

NOISE UNLIMITED, INC.

104 S. Bridge St., Somerville, N.J. 08876

29 February 1988

Performed	Checked	Approved
J. B. Moncrief	G. McAdoo	R. D. McAdoo
<i>J. B. M.</i>	<i>R. D. McAdoo</i>	<i>R. D. McAdoo</i>
28 MAR 1988	for G.M. 3-29-88	29 March 88

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9.0	Test Witnesses	3
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NOISE UNLIMITED, INC.
SOMERVILLE, NEW JERSEY

Report No. 4773.01
Page 2

1.0 Purpose of Test

The purpose of this test was to record sound pressure levels emitted by the RICOR 1/4 Watt Split.

2.0 Manufacturer

Cryo-Tek Corp.
3589 Forest Dale
Woodbridge, Virginia 22193

3.0 Manufacturer's Type or Model No.

RICOR 1/4 Watt Split
P/N K516 CT-45
S/N 013

4.0 Drawing, Specification or Exhibit

Night Vision Electro Optics Specification 82-28A050122A
HD1045 Cooler
18 June 1982
Para. 7.2.2

5.0 Number of Items Tested

One (1)

6.0 Security Classification of Items

Unclassified

7.0 Date Test Completed

17 February 1988

8.0 Test Conducted By

Noise Unlimited, Inc.
Somerville, NJ 08876

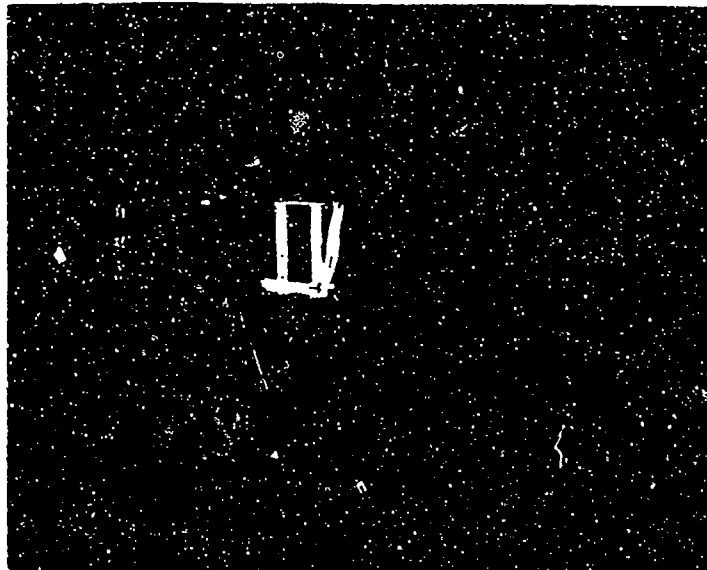
9.0 Test Witnesses

Mr. B. T. Walters, Cryo-Tek Corp. Representative
Mr. H. Kling, Cenvco Representative

10.0 Disposition of Items Tested

NOISE UNLIMITED, INC.
SOMERVILLE, NEW JERSEY

Report No. 4773.01
Page 3



Test Item Suspension

Figure 1

NOISE UNLIMITED, INC.
SOMERVILLE, NEW JERSEY

Report No. 4773.01
Page 5

DATE 2-17-88

NUI Form #12

A-50

<u>Position</u>	<u>Description</u>	<u>Axis</u>
1	Cold Finger End	X
2	Side A	Z
3	Pover End	X
4	Side B	Z
5	Opposite Cold Finger Side	Y
6	Cold Finger Side	Y

The microphone was positioned at a distance of 1 meter from the side of the test item. The microphone was positioned with a 0° angle of incidence.

Measurement Positions

Table 1

NOISE UNLIMITED, INC.
SONERVILLE, NEW JERSEY

Report No. 4773.01
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Octave Band Center Frequencies

<u>Position</u>	<u>125</u>	<u>250</u>	<u>500</u>	<u>1K</u>	<u>2K</u>	<u>4K</u>	<u>8K</u>	<u>O/A dBC</u>
Ambient 4	37	27	24	30	20	10	<10	51
4	-	-	-	-	-	-	-	54
1	-	-	-	-	-	-	-	53
2	-	-	-	-	-	-	-	53
3	-	-	-	-	-	-	-	51
6	-	-	-	-	-	-	-	54
5	32	30	38	43/45	50/54	42/44	39/42	55
Ambient 5	32	27	22	18	26	13	<10	48
5**	18	16	24	29/31	36/40	28/30	25/28	41

Spec.

Maximum*** 49.5 48.5 43.5 35.5 29.5 29.5 26.5

*Meter on slow/noise was cycling.

**Equivalent sound pressure levels for a distance of 5 meters using the following formula:

$$SPL1 = SPL2 - 20 \log D1/D2$$

Where:

SPL2 = Sound pressure level at distance D2

***Specification Paragraph 7.2.2

Measurement Data (dB re: .0002 Microbar)

Table 2

NOISE UNLIMITED, INC.
SOMERVILLE, NEW JERSEY

Report No. 4773.01
Page 8

LIST OF APPARATUS

<u>Item</u>	<u>Manufacturer</u>	<u>Model No.</u>	<u>S/N</u>	<u>Cal. Date</u>	<u>Due Date</u>	<u>Accuracy</u>	<u>Range</u>
3. Microphone	Brue1/Kjaer	4131	191648	Before/After Test		$\pm 1dB$	20Hz-10kHz
11. Pistonphone	Brue1/Kjaer	4220	284823	04-28-87	04-28-88	$\pm .2dB$	250Hz
16. Prec.Sd.Lvl.Mtr.	Brue1/Kjaer	2204	313737	11-11-87	11-11-88	$\pm 1dB$	2Hz-70kHz
20. Oct.Fltr.Set	Brue1/Kjaer	1613	325994	11-11-87	11-11-88	$\pm .5dB$	22Hz-45kHz

NOISE UNLIMITED, INC.
SOMERVILLE, NEW JERSEY

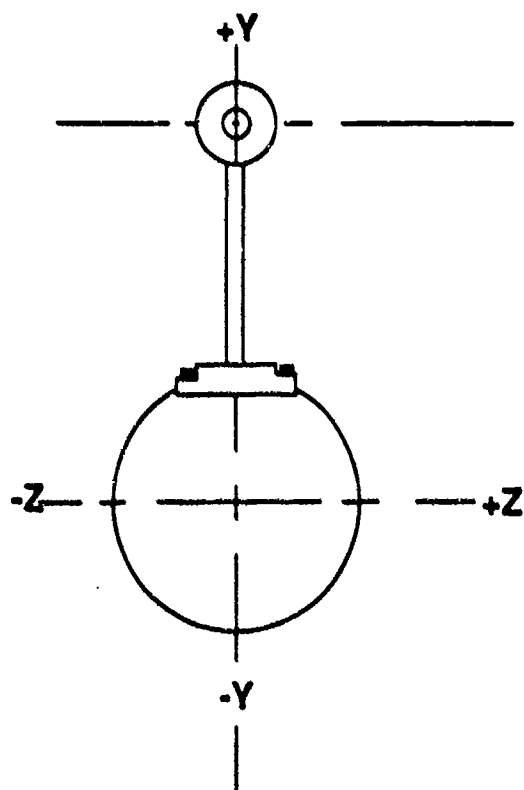
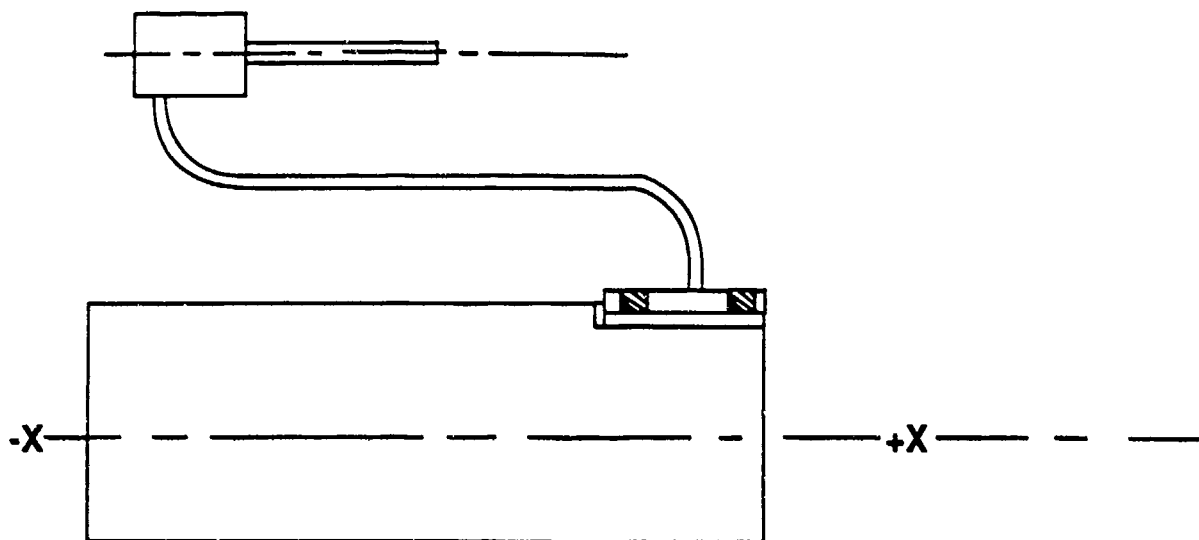
Report No. 4773.01
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ACOUSTIC NOISE

C²NVEO DATA

Two RICOR 1/4-Watt Split Rotary Coolers, S/N 8011 and S/N 013, were tested to determine their audible noise levels. The coolers were suspended with rubber bands in the C²NVEO firing range (semi-anechoic room). The ambient octave band sound pressure levels were then recorded with the required DC power supply operating. The cooler was then allowed to cool down. The overall sound pressure level data was then recorded. All measurements were taken at a distance of 1 meter from the cooler. The specification maximum sound pressure levels were then converted to 1-meter levels. As can be seen from the data, both coolers exceeded the maximum levels in +Y and +Z axes at the 2,000, 4,000, and 8,000 center frequencies.

MECHANICAL VIBRATION ORIENTATION



SOUND PRESSURE LEVEL MEASUREMENTS

DATE <u>8 June</u>		TEST ENGINEER <u>H. KUNG</u>											
PRIMARY NOISE SOURCE: <u>Radio # 8011 1/4 W Split</u>													
INSTRUMENTATION <u>GEN RAD 1933</u>		TIME	°F	% RH	WIND mph	DIRECTION	mm Hg	COMMENTS * FOAM WAS PLACED OVER THE CORD FINGER					
SER #													
TRANSDUCER <u>SAL 12310</u>													
TEST TIME		SOUND - PRESSURE LEVEL: dB re 20 μ N/m ² RMS											
POSITION		OCTAVE BAND CENTER FREQ: HZ											
		A-WEIGHTED	OVERALL	31.5	63	125	250	500	1K	2K	4K	8K	16K
2110		35	63	53	53	50	42	25	19	18	18	19	21
	X			53	53	49	40	31	33	40	44	36	36
	-X												
	Y			53	53	51	42	39	40	48	50	42	42
	-Y												
	Z			54	53	49	40	31	35	46	46	42	38
	-Z												
		MAX. SPL PERMITTED BY SPEC. AT 1 M.				63.5	62.5	57.5	49.5	43.5	43.5	40.5	

S/N 8011

DATE _____ P. JUNE 98						TEST ENGINEER H. KLING							
PRIMARY NOISE SOURCE: Rick #013 ¼ W SPRT													
	TIME	"F"	%RH	WIND mph	DIRECTION	mmHg							
	1900	70	?	0	-								
<u>INSTRUMENTATION</u> GENRAD 1933 <u>SFR</u> <u>TRANSDUCER</u> SAV 12310							COMMENTS * FORM WAS PLACED OVER THE COCO FINGER						
							SOUND - PRESSURE LEVEL: dB re 20 µN/M² RMS						
TEST TIME NO.	POSITION						OCTAVE BAND CENTER FREQ: Hz JB						
		A-WEIGHTED	OVERALL	31.5	63	125	250	500	1K	2K	4K	8K	16K
1	1995	BURBANK SOUND	63 dB	52	52	47	42	24	19	18	18	19	21
	X	49	64	52	52	47	41	37	36	43	44	37	36
	-X	50	64										
	/	56	64	53	52	50	42	39	45	48	45	43	40
	-Y	55	64										
	Z	53	64	52	52	48	41	35	44	51	46	42	41
	-Z	54	63										
FAR SPEC.													
	MAX. PERMITTED AT 1 meter		-	-	-	63.5	62.5	57.5	41.5	43.5	43.5	40.5	-

VIBRATION OUTPUT

Self-Induced Vibration Test of RICOR/CRYO-TEK 1/4-Watt Split Cooler

Three RICOR 1/4-Watt Split Rotary CRYO-Coolers were tested to determine the vibration characteristics. The coolers were freely suspended so that the linear and angular restraints would not affect the measurements. The accelerometers were mounted in pairs to facilitate the angular vibration components. From the acceleration measurements, the forces and torques generated by the cooler were determined.

Measurements of the three RICOR coolers show that the primary disturbances generated by the cooler are 1) Forces at the compressor in the direction of the Y and Z axis at the fundamental frequency, 2) A torque about the compressor axis (X AXIS) at the first harmonic, and 3) A force along the coldfinger AXIS at the first, second or third harmonic.

A schematic of the test set up is shown. An aluminum block/collar was clamped around the compressor to facilitate accelerometer mounting. The coldfinger was suspended below the compressor and covered with foam insulation. The cooler was suspended by a bungy cord arrangement that allowed free rotation about the C.G. and free translation. The natural frequency of the suspension system was determined to be less than 5 Hz.

An accelerometer was mounted to the cooler system in one of the positions (X, Y, Z). The linear accelerations along the X, Y, Z axis were determined by measuring the spectrum of the resulting signals with an HP-3561A, dynamic signal analyzer. The force generated by the compressor or coldfinger about the C.G. was determined by multiplying the weight of the cooler system by the measured acceleration. The weight of the cooler and accelerometer mounting block is 2.14 pounds. Thus, if "a" is acceleration, the force is:

$$F_x = 2.14 \times a$$

$$F_y = 2.14 \times a$$

$$F_z = 2.14 \times a$$

The torque generated by the compressor was obtained by coherently summing the accelerometer outputs of two accelerometers. The torque required to generate the measured acceleration was determined by multiplying this measurement by the inertia of the cooler system about the appropriate axis and by dividing by the distance between the accelerometers. The moments of inertia were determined by the bifilar torsional pendulum method.

$$I_{xx} = 0.856 \text{ in-Oz-sec}^2$$

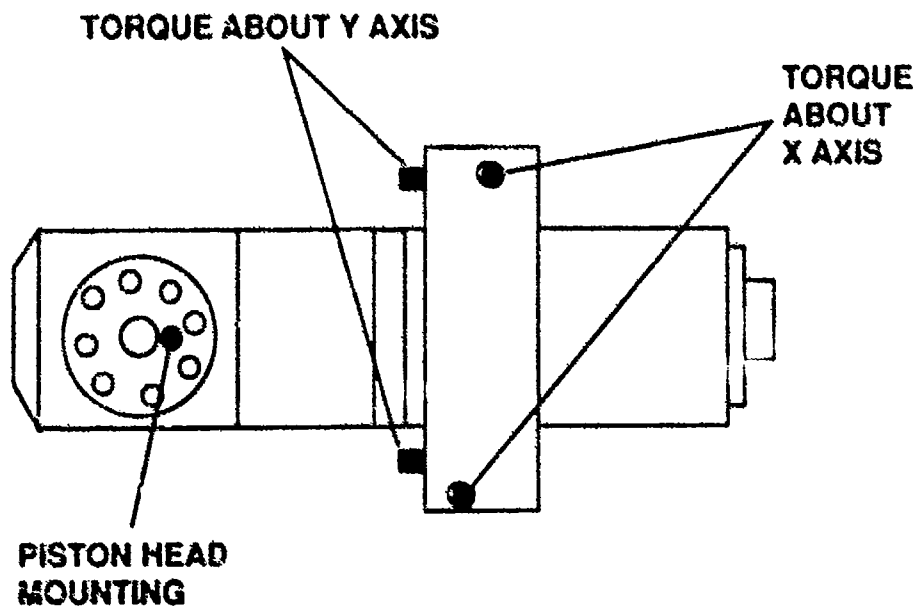
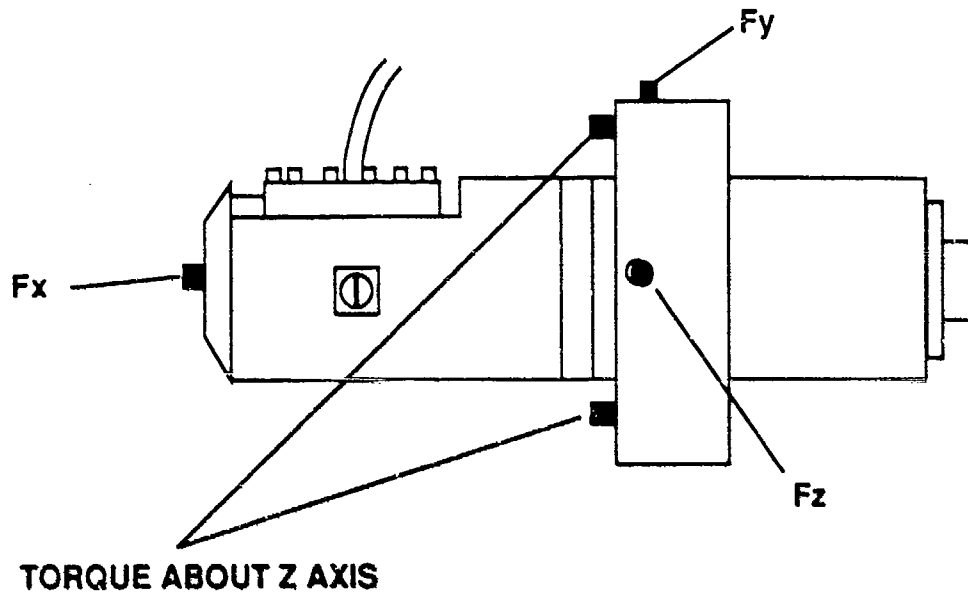
$$I_{yy} = 0.1663$$

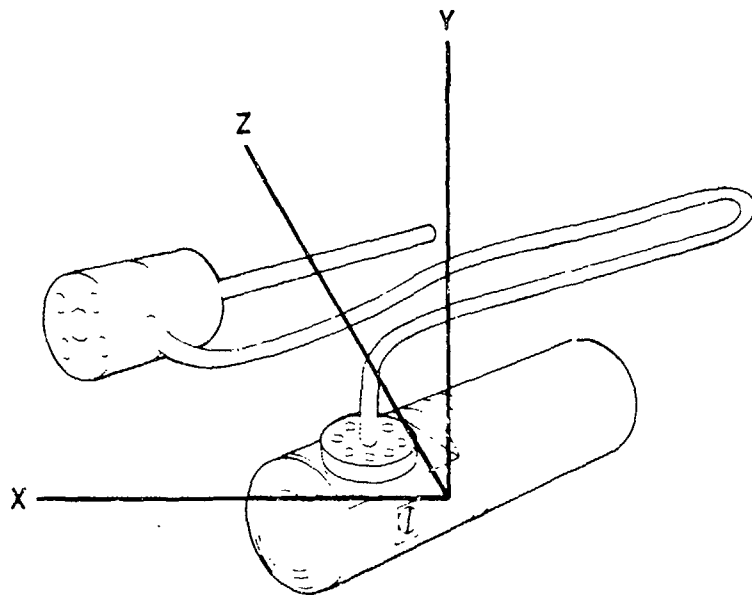
$$I_{zz} = 0.1936$$

Power spectral data for the force and torque measurements are shown in the following graphs.

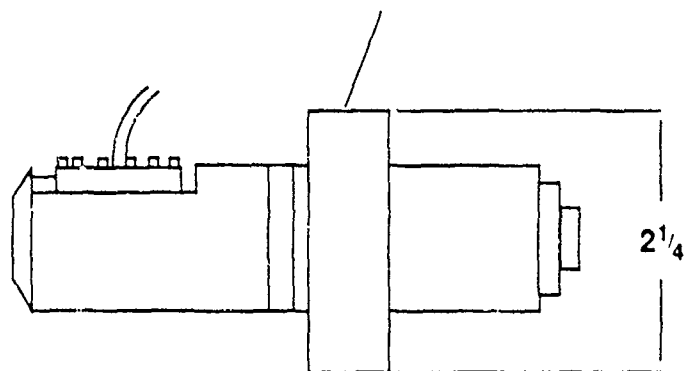
This vibration test was performed to determine the vibration output of the coolers. There is no accept or reject requirement for this test.

ACCELEROMETER MOUNTING

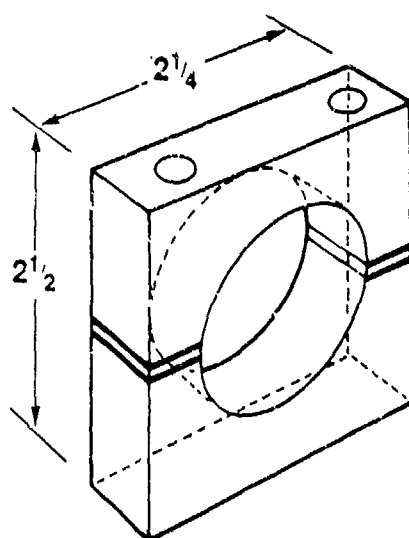




ACCELEROMETER MOUNTING BLOCK/COLLAR



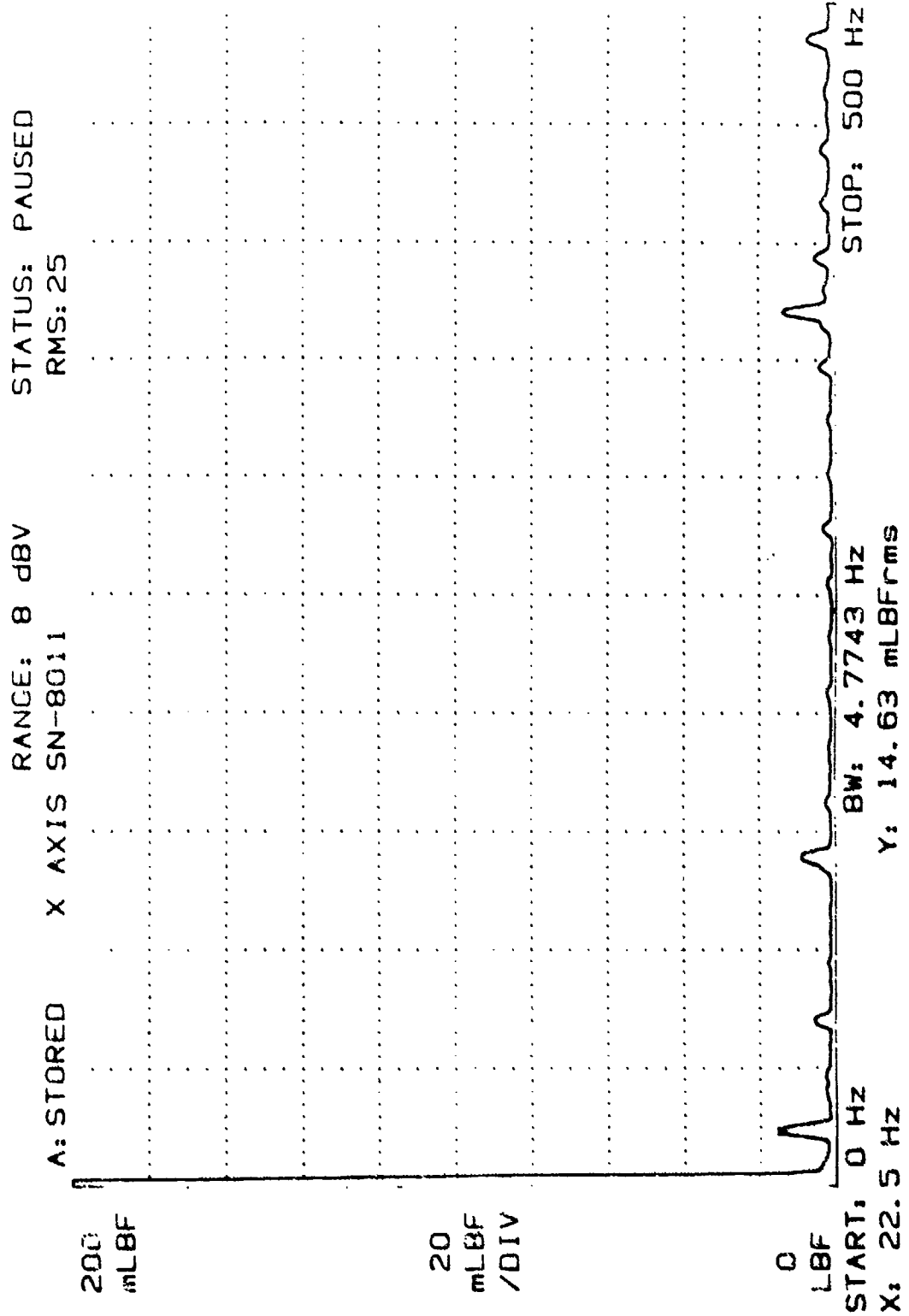
— || — $\frac{1}{16}$



ACCELEROMETER MOUNTING
BLOCK/COLLAR: 174gr/0.384 LB

TOTAL WEIGHT OF COOLER
AND MOUNTING BLOCK: 2.14 LB

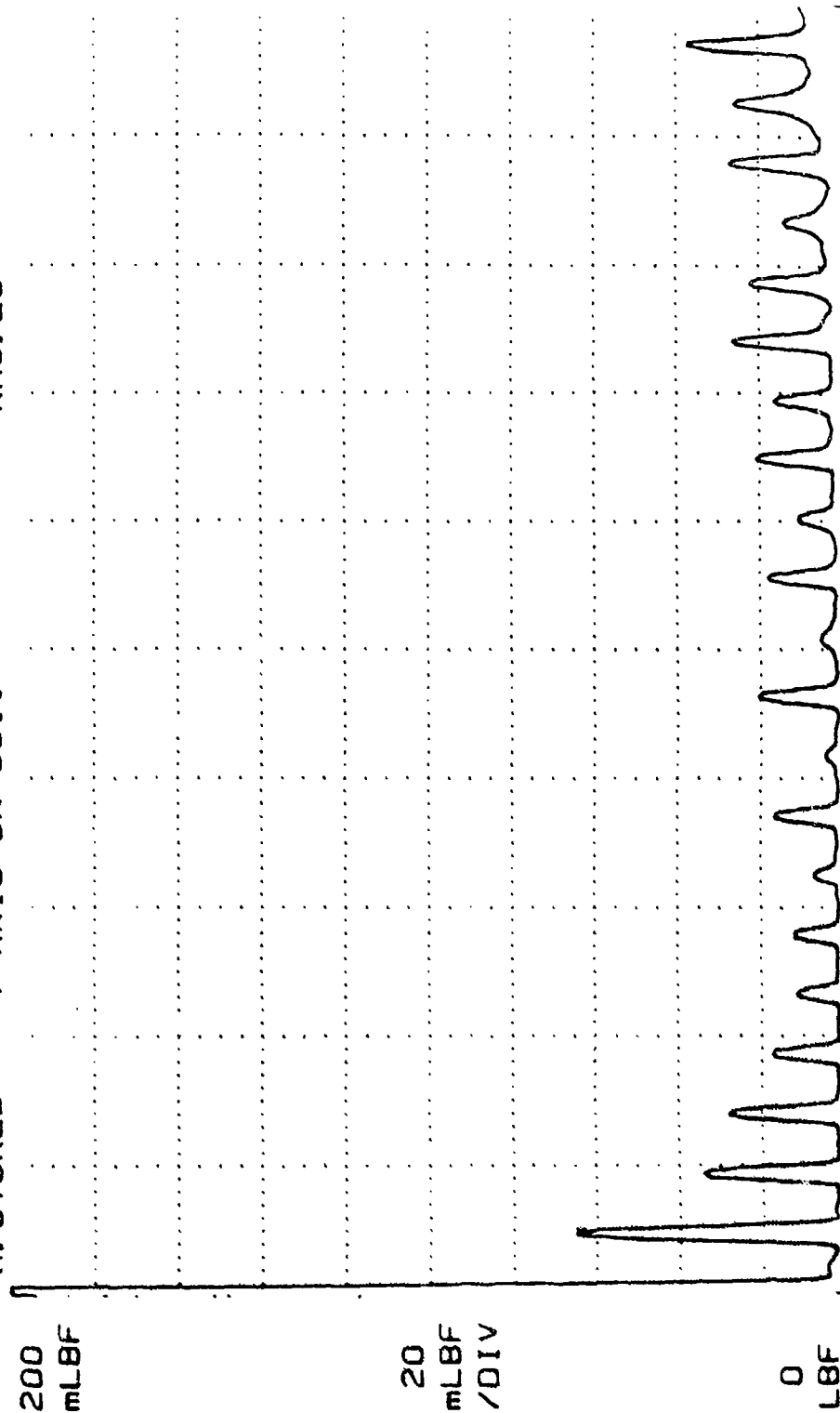
VIBRATION OUTPUT—S/N 8011



STATUS: PAUSED
RMS: 25

RANGE: 8 dBV
Y AXIS SN-8011

A: STORED



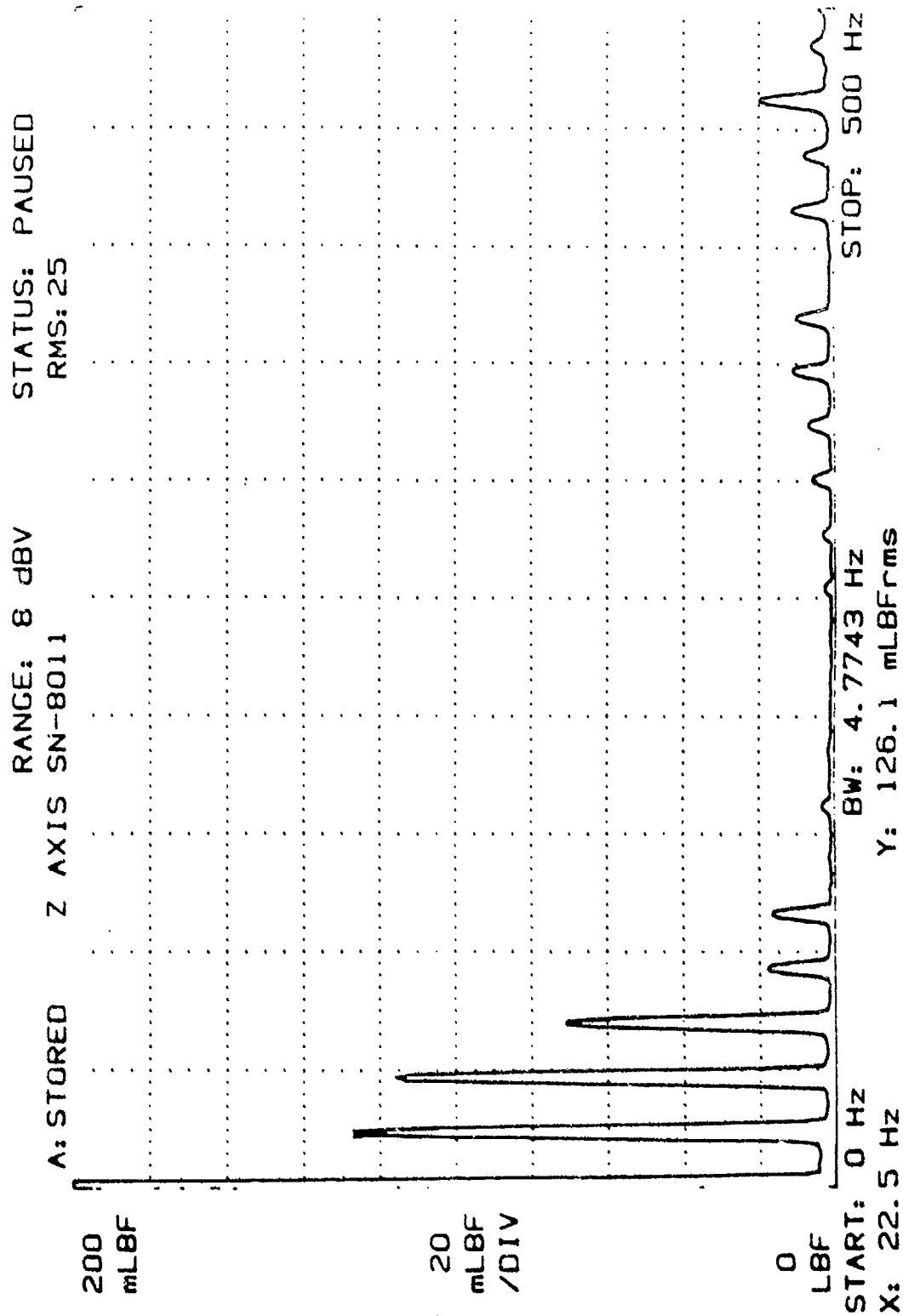
STOP: 500 Hz

BW: 4.7743 Hz

START: 0 Hz

Y: 63.99 mLBfms

X: 23.75 Hz



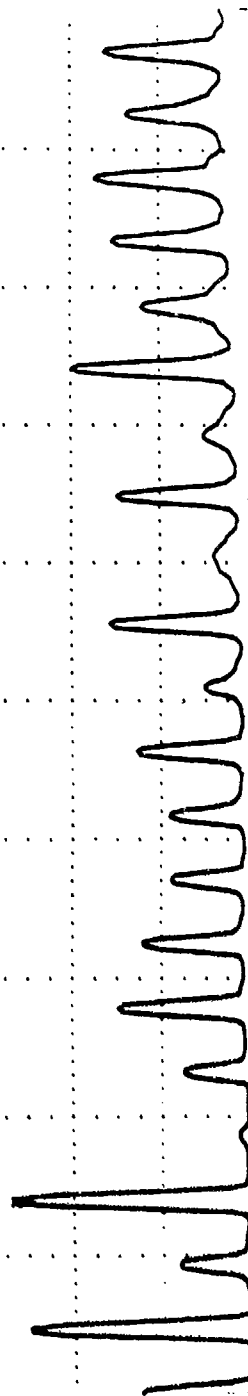
STATUS: PAUSED
RMS: 25

RANGE: 8 dBV
CF SN-8011

A: STORED

200
mLBF

20
mLBF
/DIV



0
LBF

START: 0 Hz
X: 68.75 Hz

BW: 4.7743 Hz
Y: 52.91 mLBFrms

STOP: 500 Hz

STATUS: PAUSED
RMS: 25

RANGE: 8 dBV
TRQ X AXIS SN-8011

A: STORED

25
OZI

2.5
OZI
/DIV

0
OZI

START: 0 Hz
X: 46.25 Hz

BW: 4.7743 Hz
Y: 20.72 OZIrms

STOP: 500 Hz

STATUS: PAUSED
RMS: 25

RANGE: 8 dBV
TRQ Y AXIS SN-8011

A: STORED

25
OZI

2.5
OZI
/DIV

0

START: 0 Hz
X: 22.5 Hz

BW: 4.7743 Hz
Y: 1.648 OZirms

STOP: 500 Hz

STATUS: PAUSED
RMS: 25

RANGE: 8 dBV
TRQ Z AXIS SN-8011

A: STORED

25
0Z1

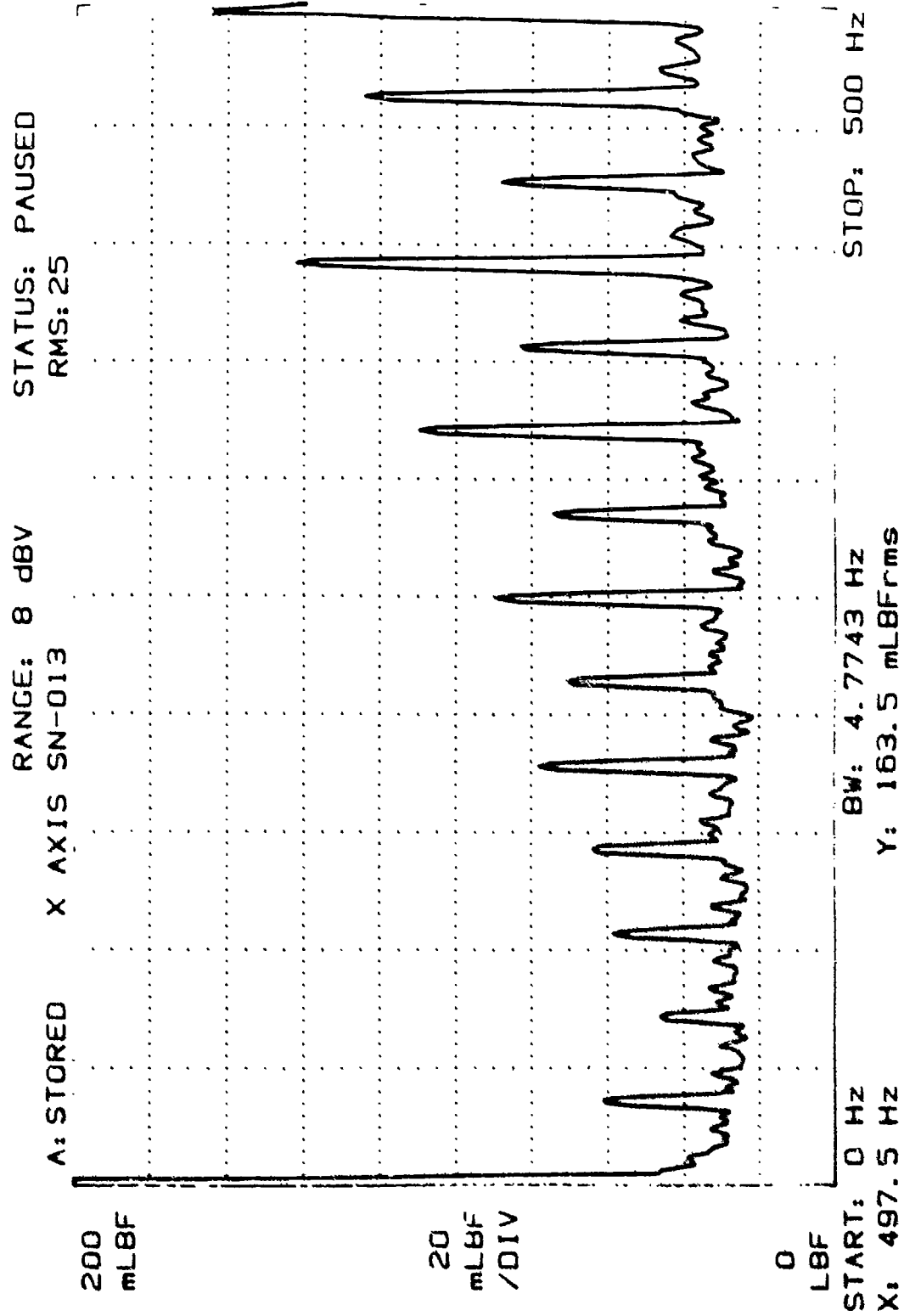
2.5
0Z1
/DIV

0

START: 0 Hz
X: 22.5 Hz

BW: 4.7743 Hz
Y: 2.608 0Z1rms

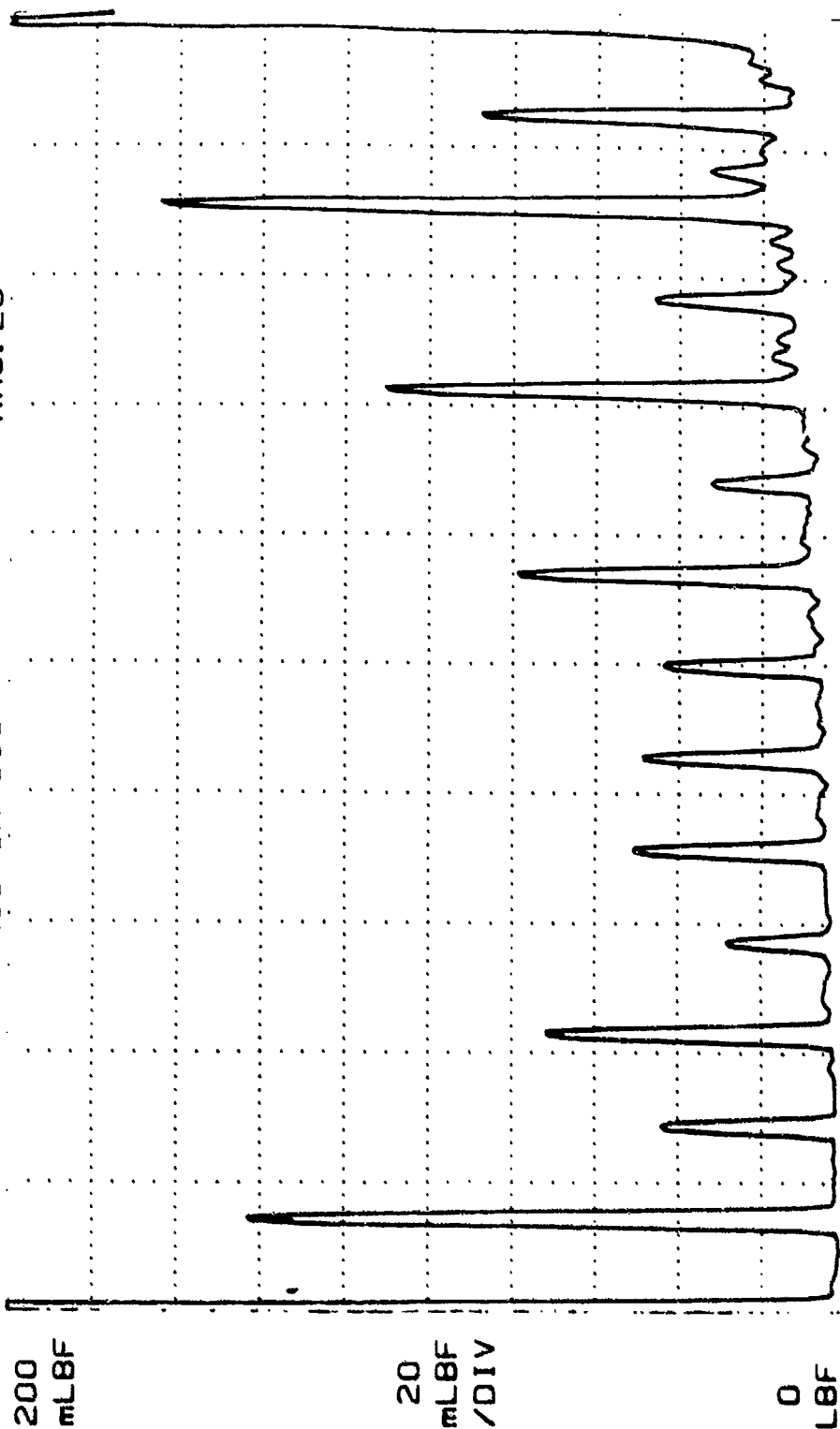
STOP: 500 Hz



STATUS: PAUSED
RMS: 25

RANGE: 8 dBV
Y AXIS SN-013

A: STORED



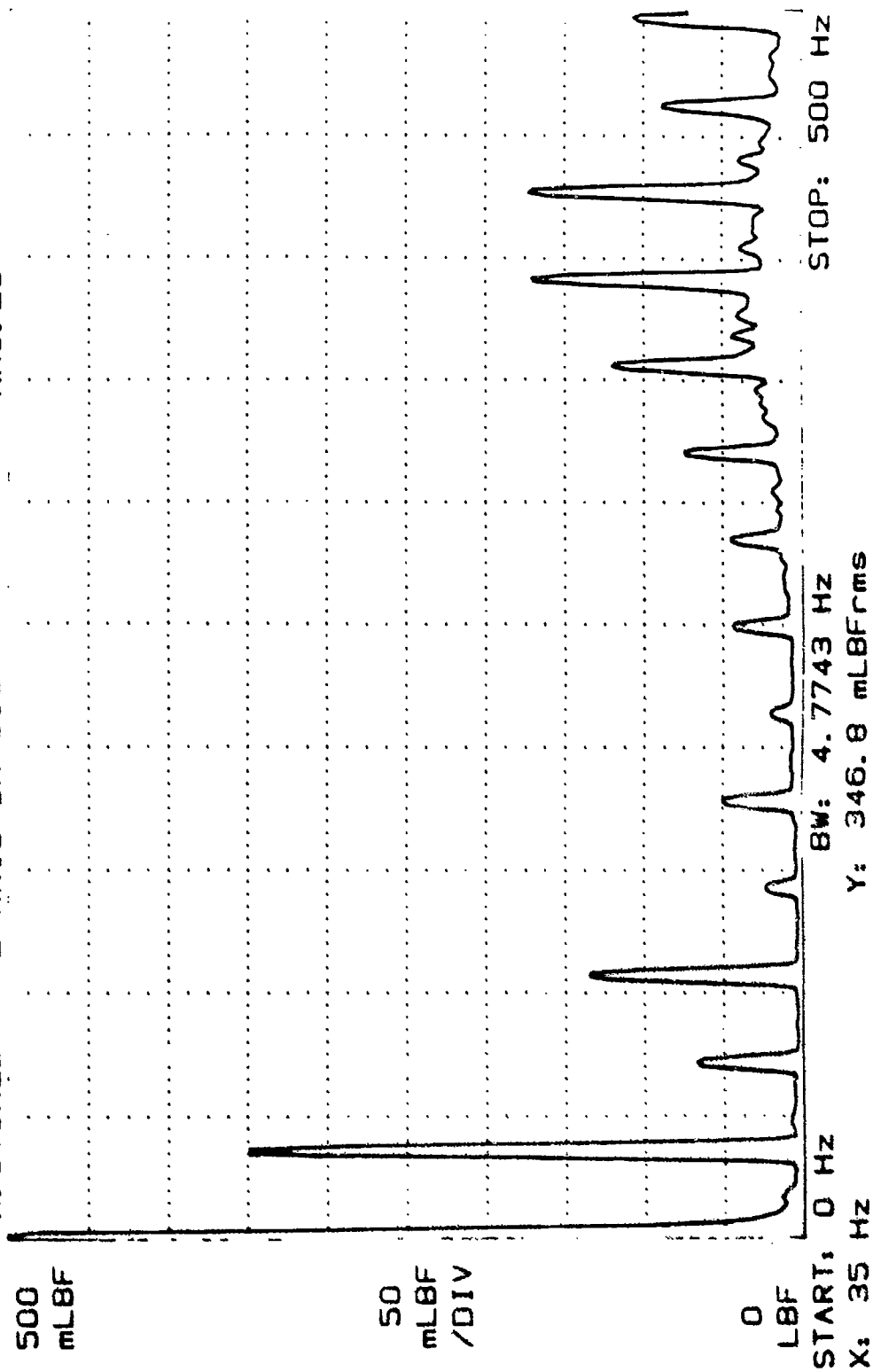
BW: 4.7743 Hz
Y: 231.0 mLBf rms

START: 0 Hz
X: 497.5 Hz

STATUS: PAUSED
RMS: 25

RANGE: 8 dBV
Z AXIS SN-013

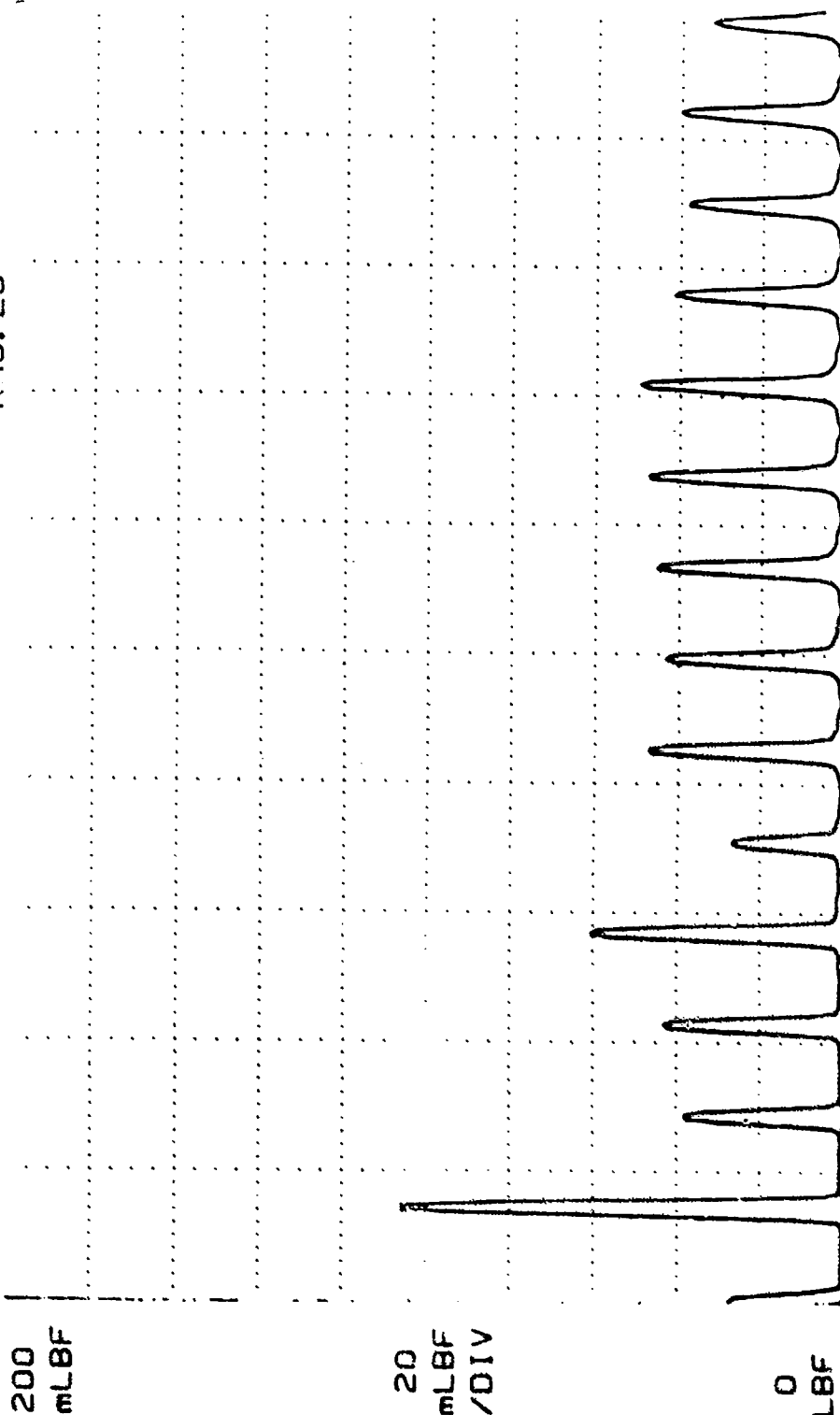
A: STORED



STATUS: PAUSED
RMS: 25

RANGE: 8 dBV
CF SN-013

A: STORED

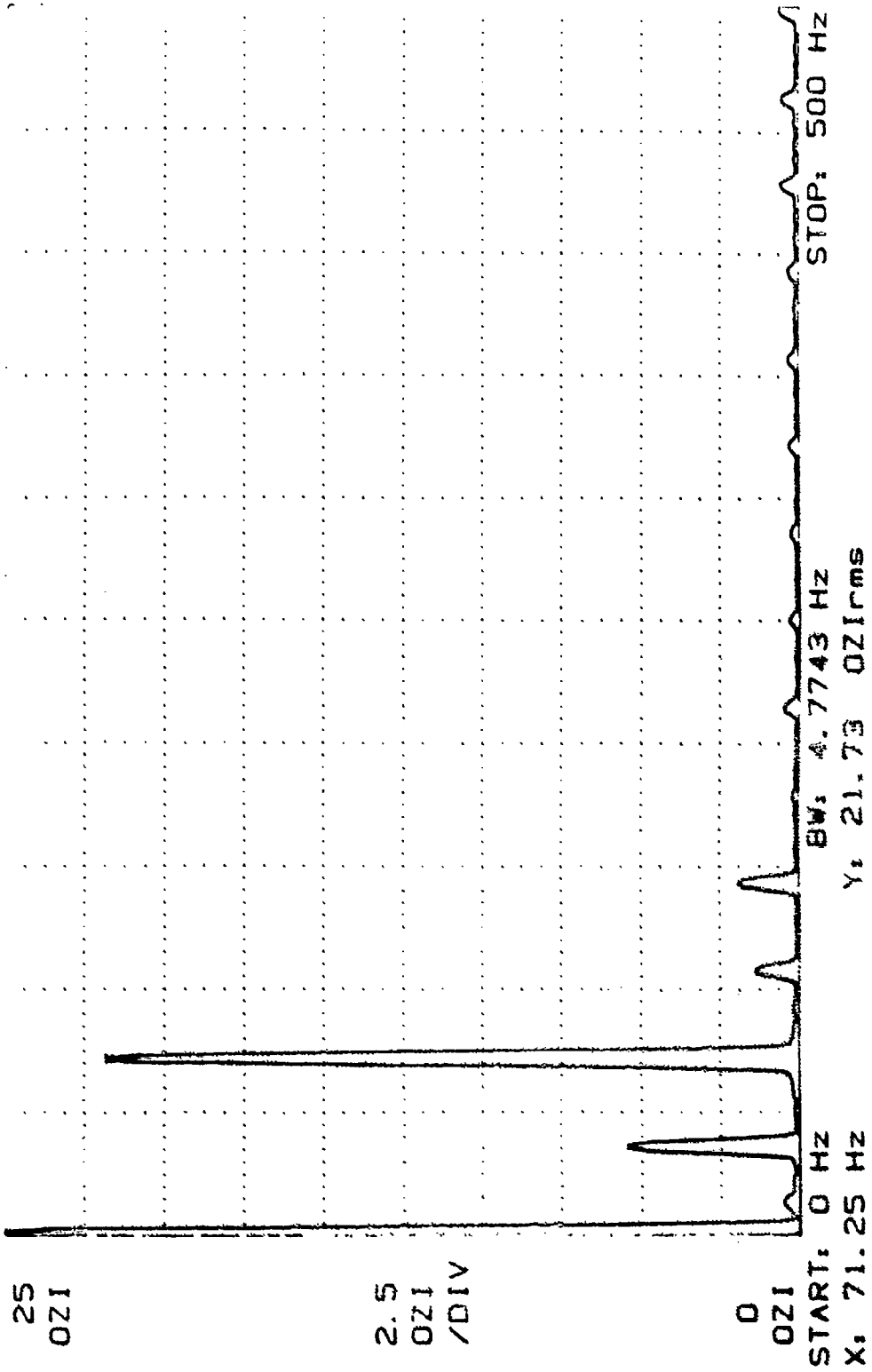


START: 0 Hz
X: 35 Hz
BW: 4.7743 Hz
Y: 105.0 mLBfms
STOP: 500 Hz

STATUS: PAUSED
RMS: 25

RANGE: 8 dBV
TRQ X AXIS SN-013

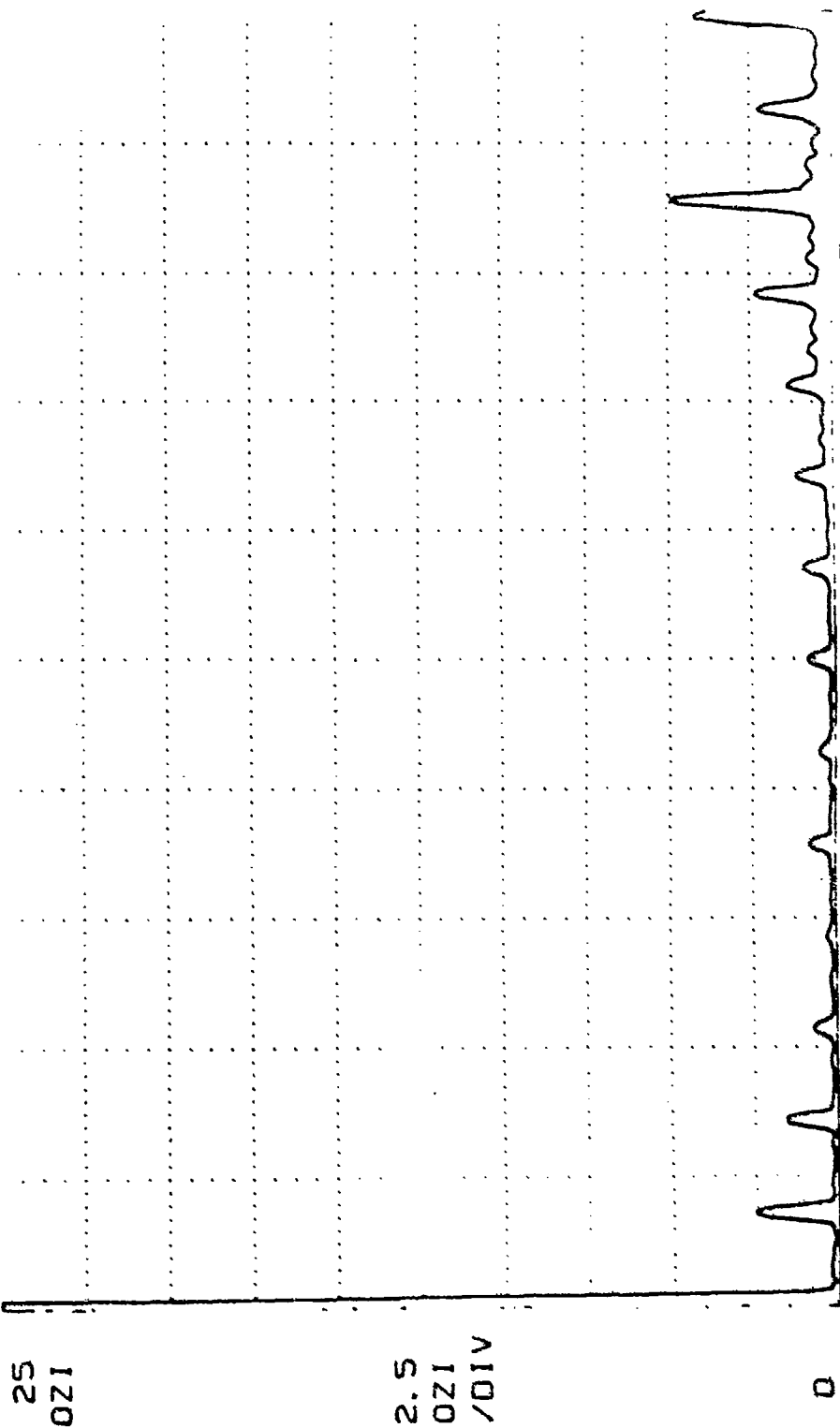
A: STORED



STATUS: PAUSED
RMS: 25

RANGE: 8 dBV
TRQ Y AXIS SN-013

A: STORED



START: 0 Hz

BW: 4.7743 Hz

Y: 4.798 021rms

X: 427.5 Hz

STATUS: PAUSED
RMS: 25

RANGE: 8 dBV
TRQ Z AXIS SN-013

A: STORED

25
OZI

2.5
OZI
/DIV

0

STOP: 500 Hz

BW: 4.7743 Hz

Y: 7.657 OZirms

START: 0 Hz

X: 498.75 Hz

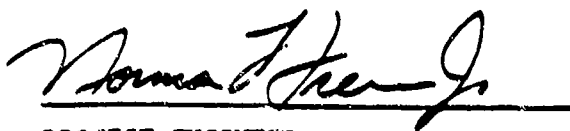
APPENDIX B
TEST PROCEDURES

B2-28A050122A
CODE IDENT: 54490
18 June 1982

DEVELOPMENT SPECIFICATION FOR
COOLER, CRYOGENIC, SPLIT STIRLING

HD-1045 (V) /UA

APPROVAL:



PROJECT ENGINEER



CONFIGURATION MANAGER
NIGHT VISION & ELECTRO-OPTICS LAB
DATE: 18 June 1982

OFFICIAL RELEASE: NV&EOL ERR NO: 28A122-004

DEVELOPMENT SPECIFICATION
FOR
COOLER, CRYOGENIC, SPLIT STIRLING HD-1045 (V) /UA

1. SCOPE

1.1 General. This specification establishes the general performance design, development, and test requirements for the several models of the Coolers, Cryogenic, Split Stirling, HD-1045(V)/UA, hereafter referred to as the cooler.

1.2 Models. Specific coverage of each model of the HD-1045 (V) /UA are contained in specification sheets which are used to supplement this general specification.

2. APPLICABLE DOCUMENTS

2.1 Government documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of the specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

SPECIFICATIONS

Military

MIL-P-1116

DOD-D-1000

MIL-I-8500

MIL-Q-9858

MIL-P-11268

MIL-M-13231

MIL-E-55585

MIL-S-83490

Preservation - Packaging, Methods of
Drawings, Engineering and Associated List
Interchangeability and Replaceability of
Component Parts for Aircraft and Missiles
Quality Program Requirements
Parts, Materials, and Processes Used in
Electronic Equipment
Marking of Electronic Items
Electronic Equipment and Parts,
Packaging of
Specifications, Types and Forms

Other Government Activity

CODE IDENT 54490

SM-D-808551

USAEADCOM, Night Vision & Electro-Optics
Laboratory
Installation/Interface Cryogenic Cooling
Systems 0.25 Watt Common Module Cooler

STANDARDS

Military

DOD-STD-100

Engineering Drawings Practices

MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-490	Specification Practices
MIL-STD-726	Packaging Requirement Codes
MIL-STD-781B	Reliability Tests: Exponential Distribution
MIL-STD-810	Environmental Test Methods
MIL-STD-810B	Environmental Test Methods
MIL-STD-882	System Safety Program for Systems and Associated Subsystems and Equipment, Requirements for

OTHER PUBLICATIONS

MIL-HDBK-472	Maintainability Prediction
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2.2 Non-Government documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

SPECIFICATIONS

ANSI Y32.16	Reference Designations for Electrical and Electronic Parts and Equipment
ANSI S1.11	Specification for Octave, Half Octave, and Third Octave Band Filter Sets

(American National Standards Institute, Inc.,
1430 Broadway, New York, New York 10018)

Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.

3. REQUIREMENTS

3.1 Item definition. The cooler shall consist of a compressor assembly, an expander assembly, and a connecting transfer line for cooling an infrared detector and shall interface with the Dewar of the infrared Detector/Dewar package DT-591/UA. Model variations are for length and bend configuration of the transfer line.

3.2 Characteristics.

3.2.1 Performance. Unless otherwise specified herein, the cooler shall meet the specified performance requirements at an ambient temperature of $+23^{\circ}\text{C}$, $\pm 5^{\circ}\text{C}$ and a 12-inch line separation. Heat sinking shall be sufficient to limit the crankcase temperature to 20°C above ambient.

3.2.1.1 Cooling capacity. The cooler shall provide the minimum refrigeration capacity at 85 K as shown in figure 1 over the temperature range of -40°C to $+71^{\circ}\text{C}$.

3.2.1.1.1 Specific Model Cooling Capacity. The specific model cooling capacity at the ambient temperature shall be as specified in the applicable specification sheets.

3.2.1.2 Cooldown time. The cooldown time to reach a cold spot temperature of 100 K with a 1.8 grams minimum copper mass load shall be 7.5 minutes or less. Cooldown to 85 K shall be 10 minutes or less for any temperature over the range of -40°C to $+71^{\circ}\text{C}$.

3.2.1.3 Input power. The total input power to the cooler shall be as shown in Figure 2. The input voltage shall be 17.5 Vdc ± 0.5 Vdc with a maximum voltage ripple of 10 percent at frequencies of 10 Hz or greater. Starting current shall not exceed 7 amperes for 50 milliseconds (ms) duration.

3.2.1.4 Operating mode. The cooler shall perform as specified in any geometrical orientation.

3.2.1.5 Audible noise. The cooler shall not exceed the noise values tabulated below, when measured at a distance of 5 meters:

Center Frequency (Hz)	Octave Band (Hz)	Maximum Sound Pressure Level (dB) (Reference 0.0002 microbar)
125	87 to 175	49.5
250	175 to 350	48.5
500	350 to 700	43.5
1,000	700 to 1400	35.5
2,000	1400 to 2800	29.5
4,000	2800 to 5600	29.5
8,000	5600 to 11200	26.5

3.2.1.6 Leak rate. The leak rate of helium from the cooler shall not be greater than 1.0×10^{-6} standard (std. cc/sec) cubic centimeters per second (cc/sec) air equivalent at an ambient temperature of $+23^{\circ}\text{C}$, $\pm 5^{\circ}\text{C}$.

3.2.2 Physical characteristics.

3.2.2.1 Size. The size and configuration of the cooler shall be in accordance with that specified on drawing SM-D-808551 as modified by the applicable specification sheet for the individual item.

3.2.2.2 Weight. The weight of the cooler shall be less than 2.5 pounds.

3.2.3 Reliability. The cooler shall have a specified mean time between failure (MTBF) of 1,000 hours, θ_0 .

3.2.4 Maintainability. The cooler shall be designed to be maintainable by the Direct/General Support (DS/GS) maintenance level when disassociated from its next higher assembly. The maintenance tasks shall consist of purging and recharging the cooler with helium and repairing/replacing the input power cable and connector. The mean time to repair (MTTR) for the DS/GS tasks shall not exceed 0.5 hour. Putting cure time is not considered within the MTTR definition.

3.2.5 Environmental conditions. The cooler performance shall not be degraded when subjected to the environments specified in table 1.

3.2.6 Transportability. When properly packaged, the cooler can be shipped by common carrier.

3.3 Design and construction.

3.3.1 Materials, processes, and parts. Unless otherwise specified, all parts, materials, and processes used in construction shall be in accordance with MIL-P-11268.

3.3.1.2 Protective coatings and surface treatments. Unless otherwise specified, finishes of machines, case-forged, and welded surfaces shall be the minimum required for proper operation, good appearance, and economy of manufacture. The method of protection shall in no way prevent compliance with other requirements of this specification. Protective coatings shall not be applied to areas which will lose that coating during normal operation, testing, or maintenance. The cooler shall be finished in accordance with the applicable specification sheet.

Table I. Environmental Conditions.

<u>Environment</u>	<u>Levels</u>	<u>MIL-STD-810</u>
High Temperature	Operation +71°C Storage +71°C	501.1 Procedure I
Low Temperature	Operation -40°C Storage -57°C	502.1 Procedure I
Temperature Shock	-54°C to +71°C	503.1 Procedure I
Solar Radiation	W/O container	505.1 Procedure I
Fungus	28 Days W/O container	508.2 Procedure I
Salt fog	W/simulated Dewar	509.1 Procedure I
Dust (fine sand)	W/simulated Dewar	510.1 Procedure I
Leakage (immersion)	W/O container	512.1 Procedure I
Vibration	a. Vibration test profile figure 3. b. Cycle time of 120 min- utes per axis c. Dwell time of 1/6 cycling at each resonance	514.2 Procedures I & VIII
Shock	a. Figure 516.2-1 b. 100 g at 10 ms	516.2 Procedure IV
Temperature - Humidity-Altitude	W/container	519.2 Procedure I

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CODE IDENT: 54490
18 June 1982

3.3.2 Electromagnetic radiation. The cooler, when properly connected for operation shall comply with the following requirements of MIL-STD-461.

		<u>Deviation</u>
RE 01	Radiated emission/magnetic field, 30 Hz to 30 kHz	30 dB
RE 02 BB	Radiated emissions/electric field, 14 kHz to 1 GHz	30 dB
RE 02.1 NB	Radiated emissions/electric field, 14 kHz to 10 GHz	30 dB
*RS 03	Radiated susceptibility/electric field, 14 kHz to 10 GHz	
CE 01	Conducted emissions/dc power leads, 30 Hz to 50 kHz	30 dB
CE 04	Conducted emissions/ac power leads, 50 kHz to 50 MHz	30 dB

*The field strengths specified in MIL-STD-461 shall be modified as follows:

0.014 MHz to 2 MHz	10 volts per meter
2 MHz to 76 MHz	50 volts per meter
76 MHz to 10,000 MHz	10 volts per meter

3.3.3 Nameplates and product marking. The cooler parts, components, sub-assemblies, and assemblies thereof, shall be marked for identification per MIL-STD-130, and in accordance with MIL-M-13231, and as specified in the applicable specification sheets. Reference designation markings shall be permanent and in accordance with ANSI Y32.16. To prevent working fluid contamination, internal parts need not be marked.

3.3.4 Workmanship. Workmanship shall be in accordance with MIL-STD-454, Requirement 9.

3.3.5 Interchangeability. Parts shall be functionally and dimensionally interchangeable without selective assembly. The control of interchangeability shall be in accordance with MIL-I-8500. Within the limits imposed by performance, maximum use of parts, tools, and test equipment common to other US Army systems is essential. Compressors and expanders shall be interchangeable from one cooler to another.

3.3.6 Safety. The cooler shall be designed and fabricated to prevent injury to the operator or maintenance personnel. Safety features shall be incorporated so that any component failure will not result in conditions hazardous to personnel, in accordance with MIL-STD-454, Requirement 1. Potentially hazardous areas shall be identified in accordance with MIL-STD-882.

3.4 Documentation. The cooler shall be documented by development and product specifications prepared in accordance with MIL-S-83490 and MIL-STD-490, and by drawings prepared in accordance with DOD-D-1000 and DOD-STD-100. Variations of

cooler models shall be documented with supplemental specification sheets using this specification number with an assigned slash number (i.e. 82-28A050122A/1).

3.5 Logistics.

3.5.1 Maintenance. The maintenance concept allows for a combined DS/GS maintenance level for helium purging/recharging and repair/replacement of the input power cable and connector. No other tasks are to be performed below depot level. Depot level maintenance shall be either Government or contractor performed.

3.5.1.1 Tool and test equipment requirements. The cooler design shall be such that the need for special tools and test equipment for alignment, adjustment and maintenance is kept to a minimum. No special tools or test equipment shall be required for operator/organizational maintenance. Direct/general support maintenance shall be accomplished using standard tools and test equipment and a helium purging/recharging device.

3.5.2 Supply. The cooler shall impose no unique requirements on the supply system. The cooler is intended to be replaced as a unit at DS/GS maintenance level with a minimum of maintenance parts (purge port cover and input power cable) introduced into the supply support system.

3.6 Precedence. The characteristics of the cooler shall have priority as follows:

- a. Performance.
- b. Reliability, maintainability.
- c. Size, weight, configuration.
- d. Transportability.
- e. Safety (should be given consideration equal to each of the characteristics above).

4. QUALITY ASSURANCE PROVISIONS

4.1 General. The inspections in this section shall be conducted by the contractor to verify the performance and design characteristics specified in section 3 and the preparation for delivery requirements in section 5 are met. Quality assurance requirements are divided into four groups; initial source qualification, second source qualification, acceptance inspection, and periodic production inspections. There are five categories of quality assurance inspections; examinations, analyses, demonstrations, environmental tests, and performance tests. Supplemental specification sheets augment the quality assurance requirements herein for specific cooler models.

4.1.1 Responsibility for tests. Unless otherwise specified in the contract, the contractor shall be responsible for the performance of all tests specified herein. Except as otherwise specified, the contractor may use his own facilities. The contractor shall maintain a quality assurance program in accordance

with the requirements of MIL-Q-9858. Inspection records of the examinations and tests shall be kept complete and available to the Government as specified in the contract, and shall include a complete description of each test method and identification of the instrumentation used. The contractor is responsible for ensuring that components and materials used, are tested in accordance with the requirements of this specification and the referenced documents. The Government reserves the right to perform any of the tests set forth in this specification where such tests are deemed necessary to ensure that supplies and services conform to the prescribed requirements.

4.1.2 Special tests and examination.

4.1.2.1 Qualification, initial source. The initial qualification tests of table II shall be performed to prove the item design and the initial source supplier. Failure to meet any of the inspections of table II shall constitute failure of qualification.

4.1.2.2 Qualification, second source. The second source qualification tests of table II shall be performed to prove the capability of a second source supplier to manufacture a specific cooler without requalification of the item design. Failure to meet any of the second source inspections of table II shall constitute failure of qualification.

4.1.2.3 Acceptance inspections. Each cooler submitted for acceptance shall be subjected to the acceptance inspections of table II following the run-in of 4.1.2.5. Failure to meet any of the acceptance inspections of table II shall be cause for rejection of that cooler.

4.1.2.4 Periodic inspections. Coolers shall be sampled on a monthly basis for the periodic inspections of table II as follows:

<u>Monthly lot size</u>	<u>Number of sample units</u>
1-9	0
10-99	1
100-299	3
300-499	5
500-999	7
1000 or more	10

Failure to meet any of the periodic inspections of table II shall constitute failure of that monthly lot.

4.1.2.5 Run-in. An 8 hour continuous run-in shall be performed prior to acceptance test.

TABLE II. Quality Conformance Inspection.

Requirement	Requirement Paragraph	Inspection Criterion	Qualification Initial source	2nd source	Acceptance Inspection	Periodic Inspection
Performance:						
Cooling capacity	3.2.1.1	4.2.1.1	X	X	X	
Cooldown time	3.2.1.2	4.2.1.2	X	X	X	
Input power	3.2.1.3	4.2.1.3	X	X	X	
Operating mode	3.2.1.4	4.2.1.4	X	X		X
Audible noise	3.2.1.5	4.2.1.5	X	X		X
Leak rate	3.2.1.6	4.2.1.6	X	X	X	
Physical Characteristics:						
Size	3.2.2.1	4.2.2.1	X	X	X	
Weight	3.2.2.2	4.2.2.2	X	X		X
Reliability	3.2.3	4.2.3	X	X		
Maintainability	3.2.4	4.2.4	X			
Environmental	3.2.5	4.2.5				
High Temperature			X	X		
Low Temperature			X	X		
Temperature Shock			X	X		X
Solar Radiation			X			
Fungus			X			
Salt fog			X	X		
Dust (fine sand)			X	X		
Leakage (immersion)			X	X		X
Vibration			X	X		X
Shock			X	X		
Temp-Humid-Altitude			X	X		
Transportability	3.2.6	4.2.6	X			
Design & Construction:						
Materials, processes and parts	3.3.1	4.3.1	X			
Electromagnetic radiation	3.3.2	4.3.2	X	X		
Nameplates and product marking	3.3.3	4.3.3	X	X	X	
Workmanship	3.3.4	4.3.4	X	X	X	
Interchangeability	3.3.5	4.3.5	X	X		
Safety	3.3.6	4.3.6	X			
Documentation	3.4	4.4	X			
Logistics	3.5	4.5	X			
Preparation for delivery	5.	4.6	X	X		

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4.1.3 Test conditions. Unless otherwise specified, the cooler shall be operated at an ambient temperature of $+23^{\circ}\text{C}$, $\pm 5^{\circ}\text{C}$ using a 12-inch line separation. Adequate heat sinking or convective cooling shall be provided to ensure that the crankcase temperature does not exceed 20°C above ambient temperature.

4.2 Quality conformance inspection.

4.2.1 Performance tests.

4.2.1.1 Cooling capacity. The cooling capacity shall be measured by attaching to the cooler a test Dewar which is evacuable and contains temperature sensors and heating elements required to apply heat load. The cooler shall also have a copper mass of 1.3 grams minimum attached directly to the expander. Heat load shall be applied after achieving cooldown and capacity shall be measured not less than thirty minutes later. Failure to meet the requirements of 3.2.1.1 shall constitute failure of this test.

4.2.1.2 Cooldown time. Cooldown time shall be measured using the test Dewar and thermal mass described in 4.2.1.1. Failure to meet the requirements of 3.2.1.2 shall constitute failure of this test.

4.2.1.3 Input power. Input power shall be measured during the cooling capacity test of 4.2.1.1. Failure to meet the requirements of 3.2.1.3 shall constitute failure of this test.

4.2.1.4 Operating mode. The cooler shall be operated in the horizontal and vertical axes for a minimum of five minutes per axis with the test Dewar and thermal mass described in 4.2.1.1. Failure of the cooler to maintain the expander temperature at or below 85 K shall constitute failure of this test.

4.2.1.5 Audible noise. The cooler shall be set up in an area where the background noise level is not greater than 10 dB below the sound level to be measured. The cooler shall be operated and sound pressure measurements recorded with the cooler oriented for maximum sound level output. Measurements shall be made using an octave band analyzer with characteristics which comply with ANSI S1.11. Failure to meet the requirements of 3.2.1.5 shall constitute failure of this test.

4.2.1.6 Leak rate. The cooler shall be charged with helium to its normal operating pressure, allowed to set for at least one hour, and placed into a test chamber. Using a mass spectrometer, the leak rate shall be measured. Failure to meet the requirement of 3.2.1.6 shall constitute failure of this test.

4.2.2 Physical examinations.

4.2.2.1 Size. The cooler shall be examined for conformance to the dimensional controls of cited drawings. Failure to meet the requirements of 3.2.2.1 shall constitute failure of this examination.

4.2.2.2 Weight. The cooler shall be weighed on a scale having an accuracy of ± 0.05 pound. Failure to meet the requirement of 3.2.2.2 shall constitute failure of that examination.

4.2.3 Reliability. Cooler reliability shall be demonstrated in accordance with MIL-STD-781B, Test Plan IV A, test cycle paragraph 5.2.3.1 and figure 4. Failure to meet the requirement of 3.2.3 shall constitute failure of that demonstration.

4.2.4 Maintainability. Maintainability shall be verified by analysis in accordance with Military Handbook 472, method 2, procedure II.

4.2.5 Environmental tests. The cooler shall be subjected to the environments specified in table I at the levels specified in accordance with the specified procedure of MIL-STD-810. Failure to meet the acceptance inspections (performance) of table II following the individual test shall constitute failure of that test.

4.2.6 Transportability. When packaged as specified in section 5, the cooler shall be analyzed to determine if the requirement of 3.2.6 is satisfied. Failure to meet the requirement of 3.2.6 shall constitute failure of that analysis.

4.3 Design and construction inspections.

4.3.1 Materials, processes and parts. The cooler shall be examined for compliance with 3.3.1. Failure to meet the requirement of 3.3.1 shall constitute failure of that examination.

4.3.2 Electromagnetic radiation. The cooler shall be subjected to the tests of 3.3.2. Failure to meet the requirements of 3.3.2 shall constitute failure of that environmental test.

4.3.3 Nameplates and product markings. The cooler shall be examined to verify nameplates and product marking. Failure to meet the requirements of 3.3.3 shall constitute failure of that examination.

4.3.4 Workmanship. The cooler shall be examined for workmanship. Failure to meet the requirements of 3.3.4 shall constitute failure of that examination.

4.3.5 Interchangeability. The cooler shall be examined for interchangeability. Failure to meet the requirements of 3.3.5 shall constitute failure of that examination.

4.3.6 Safety. The cooler shall be analyzed for safety. Failure to meet the requirements of 3.3.6 shall constitute failure of that analysis.

4.4 Documentation. The cooler technical data package shall be examined. Failure to meet the requirements of 3.4 shall constitute failure of that examination.

4.5 Logistics. The cooler shall be analyzed for logistics. Failure of the cooler to meet the requirements of 3.5 shall constitute failure of that analysis.

4.6 Inspection of packaging. Packaging shall be inspected in accordance with MIL-P-116 to determine compliance with the requirements of section 5.

5. Preparation for delivery.

5.1 Preservation. Preservation shall be as specified in MIL-STD-726, coded as follows:

5.1.1 Level A. 10-1-1-00-00-NS-X-ED-0-00-A.

5.1.2 Level B. 10-1-1-00-00-NS-X-ED-1-00-B.

5.2 Packing and marking. Packing and marking shall be in accordance with MIL-E-55585.

6. NOTES

6.1 Intended Use. The cooler is intended for use in infrared systems. Installation may require additional heat sinking or forced-air cooling for the compressor depending upon the system/cooler interface.

6.2 Ordering data. Procurement documents should specify the following:

- a. Title, number and date of this specification.
- b. Title, number and date of an applicable specification sheet.
- c. Qualification of either initial or second source are required (4.1.2).
 - (1) Time frame for submission of qualification test reports.
 - (2) Time frame for approval of qualification test reports.
- d. Production delivery schedule.
 - (1) Defined in terms of monthly lots.
 - (2) Actions relative to periodic inspection failures (see 4.1.2.4).
- e. Level A or level B preservation and packaging.
- f. MIL-STD-810B may be used in lieu of the current revision of MIL-STD-810 for the shock and vibration environmental tests of 3.2.5.
- g. Requirement for contractor-generated, Government-approved acceptance test procedure.

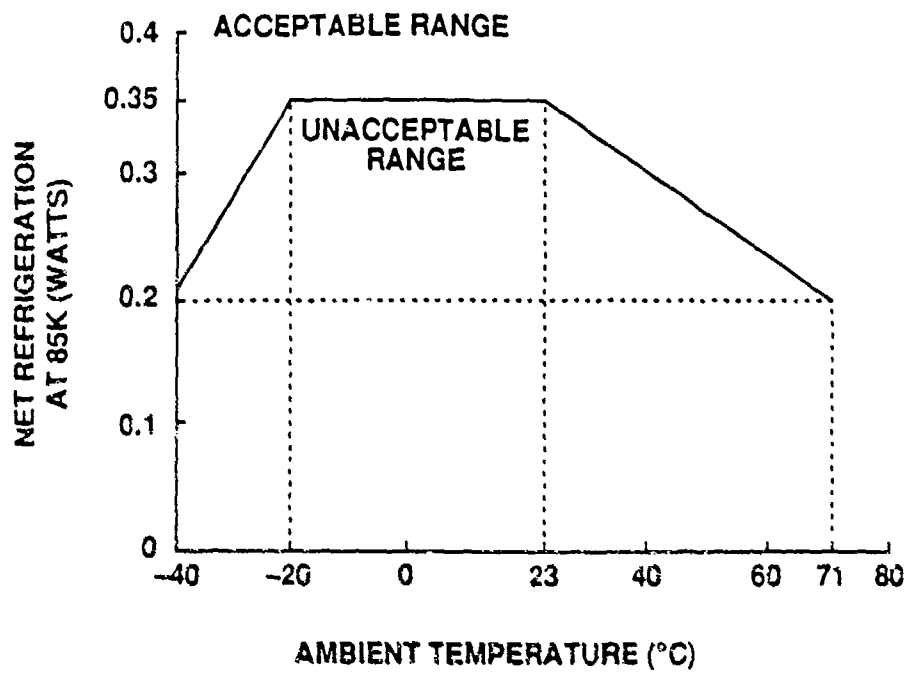


Figure 1. Cooling Capacity

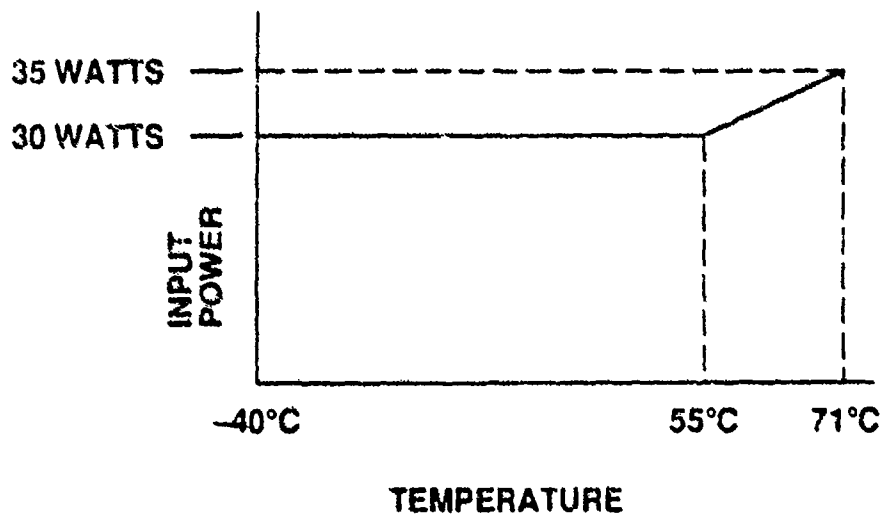


Figure 2. Input Power

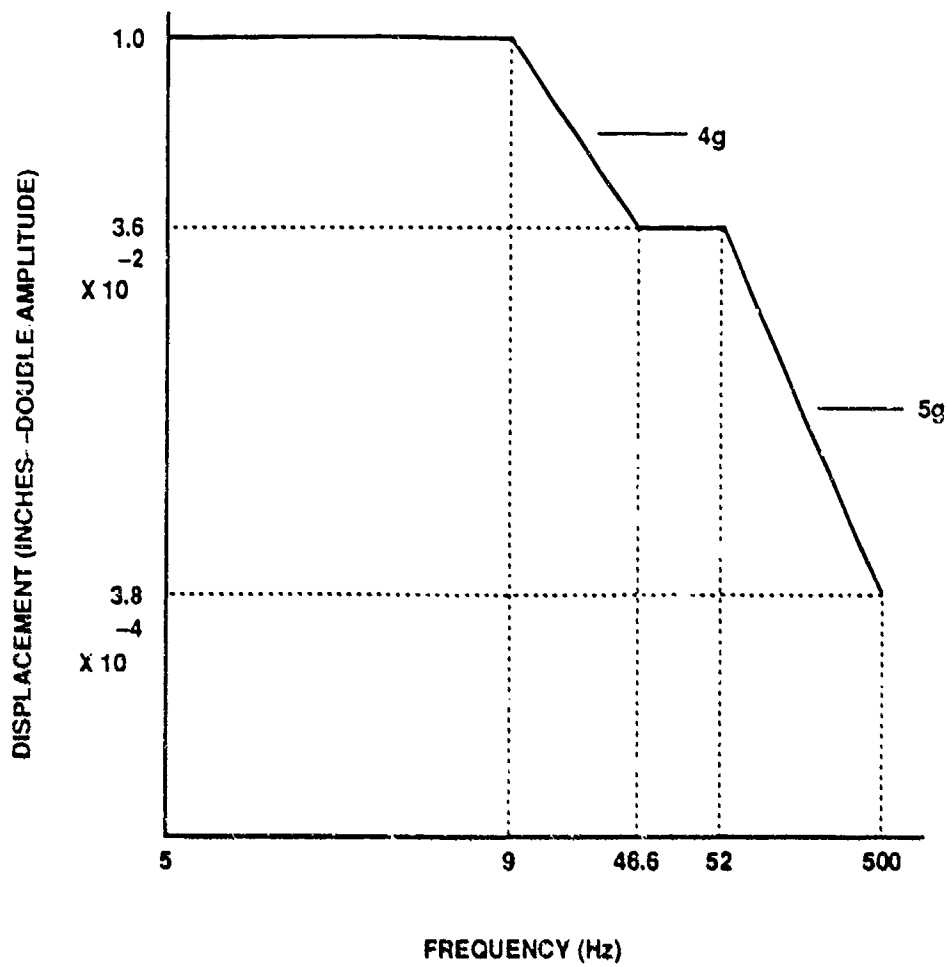


Figure 3. Vibration Test Profile

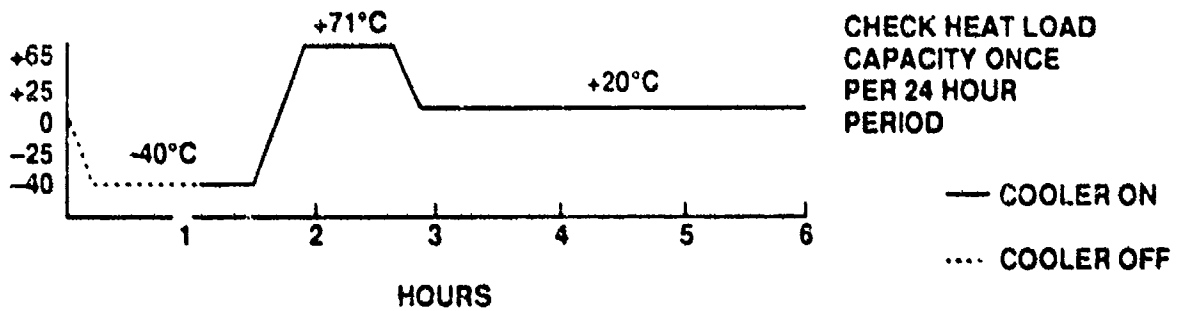


Figure 4. Reliability Test Cycle

APPENDIX C DEVELOPMENT SPECIFICATIONS


QUALIFICATION TEST PROCEDURE 1/4 Watt Split Stirling Cooler

Submitted To:

U.S. Army
Center for Night Vision
and Electro-Optics
Laboratory
Ft Belvoir, Virginia, 2206

Submitted By:
CRYO-TEK CORPORATION
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CNVEO

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1.0 SCOPE:

This document establishes the procedure to be followed for Qualification Testing of the item described in Paragraph 4.0 below.

2.0 APPLICABLE DOCUMENTS:

The following documents of revision shown form a part of this Test Procedure to the extent specified herein. In the event of any conflict between this document and the documents specified herein, this document shall take precedence.

82-28A050122A, Development Specification for Cooler, Cryogenic, Split Stirling, HD-1045 (V)/UA dated 18 June 1982.

MIL-STD-810B, Environmental Test Methods.

MIL-STD-461, Electromagnetic Emission and Susceptibility Requirements.

MIL-STD-45662, Calibration Methods.

ANSI S1.11-1971, Specification for Octave, Half Octave, and Third Octave Band Filter Sets.

3.0 QUALITY ASSURANCE PROVISIONS:

3.1 Test Facilities

Facilities providing testing shall be certified capable to meet the test requirements of MIL-STD-810B. In addition to CRYO-TEP's internal testing, RICOR Ltd. Israel and Night Vision and Electro-Optics Center, Atlantic Research will be used for the EMI testing and Noise Unlimited will be used to provide the Acoustic noise testing as necessary.

3.2 Test Surveillance

CNVED will provide test surveillance/auditing to certify accuracy of data collected including verification of test equipment, instrumentation, tooling and test fixturing shall be verified capable of meeting MIL-STD-45662, Calibration standards where applicable. Night Vision and Electro-optics Center will be the qualifying agency. CRYO-TEP will witness all testing and coordinate the effort.

4.0 TEST ITEM:

The test items shall be (5) five coolers, Cryogenic, 1/4 watt Miniature Split Stirling Model No. CT 45 (RICOR 516) herein known as the coolers or Units Under Test (UUT). Each cooler consists of a compressor, expander, and a 12 inch connecting tube which will interface with a DT-591/UA Detector/Dewar.

Three coolers will be subjected to the Reliability tests to determine the reliability of the product, and two will be subjected to the environmental conditions as prescribed in MIL-STD-883B. One of the environmental samples will be tested for EMI and audio security.

5.0 PHYSICAL CHARACTERISTICS:

5.1 Size

The cooler shall conform to the dimensions and configuration of drawing SM-D-808551

5.2 Weight

The weight of the cooler will be 2.5 lbs. or less when weighed on a scale having an accuracy of ± 0.05 lbs.

6.0 PERFORMANCE TESTS:

6.1 Tests and Performance Criteria

6.1.1 Leak Rate

The cooler leak rate shall not exceed 1.0×10^{-6} standard cubic centimeters per second air equivalent at an ambient temperature of $+23$ degrees centigrade ± 5 degrees C.

Leak tests will be performed on all coolers submitted for testing using a helium leak detector.

6.1.2 Cool Down Time

The cool down time to reach a temperature of 100° with a 1.8 grams minimum copper mass load shall be 7.5 minutes or less. Cooledown to 85° shall be 10 minutes or less for any temperature over the temperature range of -40 degrees C to $+71$ degrees C.

6.3.6 Heat sinking of the coolers shall be sufficient to limit the housing temperature to 20 degrees C above ambient.

6.3.7 Temperatures to be monitored shall be measured using T type thermocouples or by electronic thermometers mounted at the following locations:

1. Cooler housing (cooler temp)
2. Centrally located within the test chamber (chamber ambient)

6.4 Test requirement

The test shall consist of instrumenting the coolers as in paragraph 6.3 above to measure the cooldown time, refrigeration capacity, and input power of the coolers. The following performance data shall be measured and recorded on the Performance Test Data sheet at start-up and at each required time interval during test.

1. Elapsed time from start-up, Min-Sec.
2. Test chamber ambient temp. degrees C
3. Cooler Housing Temperature degrees C
4. Applied Heat Load, Watts
5. Coldfinger temp. degrees C
6. Applied Voltage, VDC
7. Input Current, Amps.
8. Test Dewar Vacuum (Torr)
9. Coldfinger Attitude, horizontal/vertical

Performance testing shall begin subsequent to the coolers having reached stabilization temperature. The coolers shall be considered to have reached stabilization when the coldfinger temperature is within ± 3 degrees of the test chamber ambient or has soaked at the required ambient temperature for four hours in a non-operating mode.

6.5 Performance Test Procedure

Insure that the coolers are instrumented in accordance with para. 6.3 of this test plan.

Step 1: Establish test set-up as outlined

Step 2: After the coolers have stabilized at the required ambient temperature, energize the coolers by applying 17.5 \pm .5 VDC to the input terminals of the coolers. The starting current shall be monitored with an oscilloscope. Verify that the input current does not exceed 7.0 amps for a period of 50 milliseconds (ms). With no heat load applied to the coldfinger, allow the cooler to cool down.

NOTE

The input voltage shall be monitored for ripple by applying a simulated nominal resistive load across the power supply output terminals and measuring the voltage ripple with an oscilloscope. AC component of voltage shall be less than 1.7 volts peak to peak at frequencies greater than 10 Hz. Record findings on the Input Power Test Data Sheet.

Step 3. Allow cooldown with no applied heat load to the coldfinger. Record data on the Performance Test Data Sheet immediately after start-up and when the coldfinger temperature reaches 85°. This procedure will be repeated for each ambient temperature specified. This shall conclude the cooldown test.

Step 4. Allow the cooler to operate for 20 minutes with no applied heat load. After 20 minutes has elapsed, record all applicable data on the Performance Test Data Sheet.

Step 5. After 20 minutes of operation, apply the required heat load which correlates to the ambient temperature of the test being performed. Allow the cooler to operate for another 20 minutes.

Step 6. Record data on the Performance Test Data Sheet at the time the heat load is applied and at 10 minutes intervals and at the end of the required time period. This shall conclude the Cooling Capacity Test.

Step 7. De-energize the coolers.

7.0 DEMONSTRATION TESTS

7.1 Operating Mode

7.1.1 Test purpose

The operating test shall be performed to verify the ability of the coolers to perform as specified in the B2 Specs. when operated in the horizontal and vertical axis as defined in this test procedure.

7.1.2 Acceptance criteria

The coldfinger temperature shall not rise above 85° when the coldfinger is in the horizontal or vertical attitudes respectively.

6.1.3 Cooling capacity

The coolers shall provide the minimum net refrigeration capacity at 85K as shown in figure 1 over the temperature range from -40 C to +71 C.

6.1.4 Input Power

The Power consumed by each cooler shall be in accordance to the chart shown in figure 2

6.2 Test Purpose

Performance testing shall be performed to verify cooler performance before, during, and after exposure to the various environmental conditions as required by this test plan. The performance test data taken after exposure to an environmental test may be used as the performance test data to be taken before the next environmental test provided that the environmental test is run within 48 hours.

6.3 Test Instrumentation

6.3.1 Those parts of the test fixtures and test equipment that are in contact with the coolers shall be visually inspected prior to and during use to insure that they are free of oil, grease, soil, or other contamination. All test instrumentation used shall be calibrated within the requirements of MIL-STD-45662.

6.3.2 The thermal mass applied shall be as defined in the Development Specification ED-284950122A. The mass shall include a silicon diode (temperature sensor) and an integral heater shall have a total mass of 1.8 grams of copper over the temperature range of 300° to 80°.

6.3.3 Each coldstation will be immersed in an ice bath and a liquid nitrogen bath to establish the calibration curve.

6.3.4 The electric voltage for operating the coolers will be set at 17.5VDC \pm .5 VDC with a maximum voltage ripple of 10 % at frequencies of 10 Hz or greater. Starting current shall not exceed 7 amperes for 50 milliseconds (ms) duration.

6.3.5 Prior to the start of performance testing the dewar assembly shall be evacuated to a vacuum level of 1.0×10^{-4} Torr or better.

7.1.3 Test Procedure:

Step 1. Instrument coolers in accordance with paragraph 6.3 of this test plan.

Step 2. Establish the test set-up as previously outlined.

Step 3. Mount the coolers in the test chamber with the cold finger and the compressor in the X axis. See figure 5.

Step 4. Energize the coolers by applying 17.5 ± 5 Volts D.C. to the input terminals of the coolers.

Step 5. Repeat the test as outlined in paragraph 6.5 step 5.

Step 6. De-energize the coolers.

Step 7. Rotate the coolers and place the coldfinger and the compressor in the Y axis. See figure 5.

Step 8. Repeat the previous test for ambient temperature and heat load.

This concludes the Operating Mode Test.

7.2 AUDIO SECURITY:

7.2.1 Test purposes:

The Audio Security test shall be performed on the cooler to determine the sound pressure levels emitted from the cooler over various frequency bandwidths. The qualifying agency has the option to choose the cooler to undergo Audio Security Testing; should the option not be exercised CFVC-TB will make the choice.

7.2.2 Acceptance Criteria:

The cooler shall not exceed the noise levels tabulated below, when measured at a distance of 3 meters:

Center Frequency	Octave Band (Hz)	Pressure Level (dB) 1.0002 dB
125	87 to 175	49.5
250	175 to 350	48.5
500	350 to 700	47.5
1,000	700 to 1,400	46.5
2,000	1,400 to 2,800	45.5
4,000	2,800 to 5,600	44.5
8,000	5,600 to 11,200	43.5

7.2.3 Test Requirement:

The Audio Security test will be performed in an anechoic chamber where the background noise level will be limited to at least 10 db below the sound pressure levels to be measured.

7.2.4.1 Test Data:

Test data shall be obtained using an octave band analyzer which complies with ANSI S1.11. The cooler shall be energized by applying 17.5 ± 5 volts D.C. to the input terminals of the cooler. Using a hand held Octave Band Analyzer, the cooler shall be surveyed to determine the location of the area of maximum noise generation. The maximum sound pressure values measured at 5 meters shall not exceed the values of the above table.

7.3 MECHANICAL VIBRATION OUTPUT:

7.3.1 Test Purpose:

The Mechanical Vibration Output Test shall be performed to determine the vibration output of the cooler when monitored at various frequencies.

7.3.2 Acceptance Criteria:

There is no accept or reject requirement for this test.

7.3.3 Test Equipment:

The cooler shall be vertically suspended such that the fundamental frequency of the cooler is not higher than the natural frequency of the suspension system.

7.3.4 Test Procedure:

- Step 1. Establish Test setup.
- Step 2. Turn on fan.
- Step 3. Energize the cooler by applying 17.5 ± 5 volts D.C. to the power input terminals of the cooler. Record start time on the Mechanical Vibration Test Sheet.
- Step 4. Allow both cooler and fan to operate for 10 minutes.
- Step 5. De-energize fan. Record time on Data Sheet.
- Step 6. Measure G1/Hz at frequency per figure 5. (Y axis)
- Step 7. De-energize cooler and permit cooler to assume ambient temperature.
- Step 8. Repeat steps 3, 4, and 5.

Step 9. Measure G2/Hz at frequency per figure 5 (Z axis) and record data.

Step 10 repeat steps 7, 3, 4, and 5.

Step 11. Measure G2/Hz at frequency per figure 5 (X axis) and record data.

Step 12 De-energize cooler.

This concludes the Mechanical Vibration Test.

8.1 ENVIRONMENTAL TESTS

8.1 Electromagnetic Radiation:

8.1.1 Test Purpose:

The Electromagnetic Radiation Test shall be performed on one (1) cooler to determine the deviation levels of radiated emissions susceptibility at specified frequencies and field strengths.

8.1.2 Acceptance Criteria:

The cooler when properly connected for operation, shall comply with the following radiated emission and susceptibility requirements of MIL-STD-461:

RE01	Rad. Emission/Magnetic field 10 Hz to 10 kHz	10db
RE02 50	Rad. Emission/Electric field 14 kHz to 1 GHz	10db
RE02.1 50	Rad. Emission/Electric field 14 kHz to 10 GHz.	10db
RES07	Radiated Emission Susceptibility/ Electric field 14 kHz to 10 GHz	
CE01	Conducted Emissions/DC Power Leads 10 Hz to 50 kHz	10db
CE04	Conducted Emissions/AC Power Leads 50 kHz to 50 MHz	10db

* The field strengths specified in MIL-STD-461 shall be specified as follows:

0.014 MHz to 2 MHz	10 volts per meter
2 MHz to 70 MHz	50 volts per meter
70 MHz to 10,000 MHz	10 volts per meter

Conduct a performance test per paragraph 5.9. of this spec.

8.2 Temperature Shock

8.2.1 Test Purpose

The Temperature Shock Test shall be conducted to determine the effect of sudden changes in temperature of the surrounding atmosphere on the coolers.

8.2.2 Acceptance Criteria

The coolers shall satisfy the requirements of paragraph 6.1 of this test plan.

8.2.3 Test Requirement-

The Temperature Shock Test shall be performed in accordance with MIL-STD-810B, Method 503.1, Procedure 1, with the exception of temperature extremes will be limited to $+71$ degrees C \pm 5 degrees C and -54 degrees C \pm 5 degrees C.

8.2.4 Test Procedure

Step 1. Install the coolers into the temperature chamber and raise the test chamber temperature to 71 degrees C \pm 5 degrees C. Allow the coolers to soak at this temperature for four (4) hours minimum or until the coolers stabilize.

Step 2. After four (4) hours minimum exposure to the high ambient soak, move the system into a test chamber with an ambient temperature of -54 degrees C \pm 5 degrees C within 5 minutes.

Step 3. Allow the coolers to soak at this temperature for four (4) hours minimum or until the coolers stabilize.

Step 4. After four (4) hours minimum exposure to the low ambient soak, return the coolers to the test chamber set at 71 degrees C \pm 5 degrees C within 5 minutes.

Step 5. Allow the units to soak at this temperature for four (4) hours minimum or until the unit stabilizes.

Step 6. Repeat steps 2 thru 5

Step 7. Repeat steps 2 and 3.

Step 8. Raise the test chamber temperature to 23 degrees C \pm 5 degrees C and allow the coolers to stabilize at standard room ambient conditions.

Step 9. Visually inspect for any evidence of mechanical damage or deterioration. Record any abnormal findings on the Temperature Shock Test Summary Sheet

Step 10. Conduct a performance test per paragraph 6.0

& leak test

This concludes the Temperature Shock Test.

8.3 THERMAL EXPOSURE

8.3.1 High Temperature

8.3.1.1 Test purpose

The High Temperature Test shall be performed to determine the resistance of the coolers to elevated temperatures that may be encountered during service life.

8.3.1.2 Acceptance Criteria

The coolers shall satisfy the requirements of paragraph 6.1 (at +23 degrees C \pm 5 degrees C and + 71 degrees C \pm 5 degrees C) of this test plan.

8.3.1.3 Test Requirement

The high Temperature test shall be performed in accordance with MIL-STD-810B, method 501.1, procedure 1.

8.3.1.4 Test Procedure

Step 1. Install the cooler, instrumented for operation, per paragraph 6.1, into a temperature chamber capable of achieving + 71 degrees C minimum (temperature rate shall not exceed 10 degreesd C/min.)

Step 2. Raise the chamber ambient temperature to + 71 degrees C \pm 1.4 degrees C.

Step 3. Allow the coolers to soak at +71 degreesC \pm 1.4 degrees C for a period of forty eight (48) hours.

Step 4. Ensure that the cooler has stabilized at + 71 degrees C. Operate the cooler in accordance with paragraph 6.0 of this test plan and record the results.

Step 5. Lower the test chamber ambient to allow the coolers (non-operating) to return to standard room temperature.

Step 6. Visually inspect the coolers for any evidence of mechanical damage or deterioration. Record any abnormal findings on the High Temperature Test Summary Sheet.

Step 7. Conduct the performance test at 23 degrees C \pm 5 degrees C per paragraph 6.0 of this test plan. Record the results of paragraph 6.1.1 on the High Temperature Test Summary Sheet.

This concludes the High Temperature Test.

8.3.2 Low Temperature

8.3.2.1 Test Purpose

The low temperature test shall be performed to determine the resistance of the coolers to low temperatures that may be encountered during service life.

8.3.2.2 Acceptance Criteria

The coolers shall satisfy the requirements of paragraph 6.1 (at -40 degrees C and 27 degrees C ± 1.4 degrees C) of this test plan.

8.3.2.3 Test Requirement

The Low Temperature Test shall be performed in accordance with MIL-STD-810B, Method 502.1, Procedure 1.

8.3.2.4 Test Procedure

Step 1. Install the coolers instrumented for operation per Paragraph 6.3, into a Temperature Chamber capable of achieving -57 degrees C minimum.

Step 2. Lower the temperature in the test chamber to -57 degrees C ± 1.4 degrees C (temperature rate shall not exceed 10 degrees C/ 10 min. Soak for twenty four hours.

Step 3. After the completion of the twenty four hours soak at -57 C ± 1.4 degrees C, visually inspect the the coolers for any evidence of mechanical damage or deterioration. Record any abnormal findings on the Low Temperature Test Summary Sheet.

Step 4. Raise temperature to -40 and allow coolers to stabilize.

Step 5. Conduct performance test at -40 C ± 1.4 degrees C per paragraph 6.0 of this test plan. Record the results of paragraph 6.1.1 on the Low Temperature Test Summary Sheet.

Step 6. Raise the temperature in the test chamber to allow the cooler to return to room ambient conditions and stabilize.

Step 7. Conduct performance test at $+27$ degrees C ± 5 degrees C per paragraph 6.0 of this plan. Record the results of paragraph 6.1.1 on the Low Temperature Summary Sheet.

Step 8. Visually inspect the cooler for any visible mechanical damage or deterioration. Record any abnormal findings on the Low Temperature Summary Sheet.

This completes the Low Temperature Test.

8.4 MECHANICAL SHOCK:

8.4.1 Test Purpose:

The Mechanical Shock Test shall be performed to determine if the coolers are constructed to withstand the expected dynamic shock stresses and that performance degradations will not be produced by the service shock environment expected in handling, transportation, and service use. The coolers shall be operated during shock test.

8.4.2 Acceptance Criteria:

The Cooler shall satisfy the requirements of paragraph 6.1 (at $27\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$) of this test plan.

8.4.3 Test Requirement:

The Mechanical Shock Test shall be performed at at $27\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ in accordance with MIL-STD 883C Method 516.2 Procedure IV, High Intensity Test. The coolers shall operate continuously during the shock portion of the test.

8.4.4 Test Procedure:

Step 1. Install a dummy load onto the shock test fixture to simulate the expected mass that will be encountered when the actual unit is installed onto the test fixture.

Step 2. Attach the test fixture and the dummy load to the moving element of the Shock Test Machine.

Step 3. Calibrate the Shock Test Machine to assure conformance to the specified waveform. Two consecutive shock applications to the dummy load shall fall within the specified tolerance envelope prior to installation of the coolers. The calibration shall conform to figure 516-1 100g for 10 ms duration.

Step 4. After the Shock Test Machine has been calibrated for conformance to the waveform, the coolers shall be installed onto the test fixture in the place of the dummy load.

Step 5. Energize the coolers and allow cooldown without the thermal mass or thermal load for ten (10) minutes.

Step 6. Apply Two (2) shocks in direction of three mutually perpendicular axes for a total of twelve (12) shock pulses. Axis identification is shown in figure 5.

Step 7. De-energize coolers.

Step 8. The coolers shall be visually inspected for any evidence of mechanical damage or deterioration. Any abnormal findings shall be recorded on the Mechanical Shock Test Summary Sheet.

Step 9. Upon completion of the Mechanical Shock Test the performance test described in paragraph 6.0 of this test plan shall be conducted at $27 \text{ degrees C} \pm 5 \text{ degrees C}$. Record the results of 6.1.1 on the Mechanical Shock Test Summary Sheet.

This concludes the Mechanical Shock Test.

8.5 Mechanical Vibration:

8.5.1 Test Purpose:

The Mechanical Vibration Test shall be performed to determine if the coolers are constructed to withstand the expected dynamic vibrational stresses that may be encountered during service life. These coolers will be operated during this test.

8.5.2 Acceptance Criteria:

The coolers shall satisfy the requirements of paragraph 6.1 (at $27 \text{ C} \pm 5 \text{ degrees C}$) of this test plan.

8.5.3 Test requirement:

The Mechanical Vibration Test shall be performed at $27 \text{ degrees C} \pm 5 \text{ degrees C}$ in accordance with MIL-STD 810B, Method 5124.2 procedures 1 & VIII, and conform to the vibration profile in figure 7. Cycle time of 120 minutes per axis with a dwell time of 1/6 cycling at each resonance. The accelerometer shall be affixed to the cooler mounting fixture.

8.5.4 Test Procedure:

Step 1. Mount the coolers onto the vibration machine with the cold finger and the compressor in the X axis. See figure 5.

Step 2. Energize the cooler and allow cooldown for 10 minutes with no thermal mass or thermal load. Record all applicable data on the Mechanical Vibration Test Summary Sheet.

Step 3. Energize the Vibration Machine and conduct a resonance search at an input level of 1g from 5-500 Hz. Record all resonant frequencies encountered.

Step 4. Select the four (4) most severe resonants recorded in step 3 and perform a resonant dwell for 20 minutes at the frequency levels specified.

Step 5. Energize the Vibration Machine in accordance with the appropriate Vibration Profile.

Step 6. Allow the coolers to vibrate in this axis for 120 minutes.

Step 7. De-energize the Vibration machine and the coolers.

Step 8. Remove the coolers from the vibration machine and visually inspect them for any evidence of mechanical damage or deterioration. Record any abnormal findings on the Mechanical Vibration Test Summary Sheet.

Step 9. Instrument the coolers per paragraph 6.3 of this test plan and mount the coolers in the Y axis. See figure 5. Repeat steps 2.3 and 4 in the Y axis.

Step 10. Energize the coolers and allow cooldown for 10 minutes with no thermal mass or thermal load.

Step 11. Energize the vibration machine in accordance with the appropriate vibration profile.

Step 12. Allow the coolers to vibrate in this axis for 120 minutes.

Step 13. De-energize the Vibration machine and remove the coolers. Inspect the coolers for any physical damage and record the results on the Mechanical Vibration Test Summary Sheet.

Step 14. Instrument the coolers per paragraph 6.7 of this test plan and mount the coolers in the Z axis. See figure 5. Repeat steps 2.7 and 4 in the Z axis.

Step 15. Energize the coolers and allow cooldown for 10 minutes with no thermal mass or thermal load.

Step 16. Energize the vibration machine with the appropriate vibration profile.

Step 17. allow the coolers to vibrate in this axis for 120 minutes.

Step 18. De-energize the vibration machine and remove the coolers. Inspect the coolers for any physical damage and record the results on the Mechanical Vibration Test Summary Sheet.

Step 19. Conduct a performance test per paragraph 6.9 of this test plan.

20. The following tests were omitted for reasons assigned. If these tests were stringently required by the Army, CRYO-TEK would gladly submit to your request.

SOLAR RADIATION: The component parts are buried in the system and are not subjected to direct solar radiation.

FUNGUS: Materials used in the fabrication are not affected by nor do they promote fungus growth.

SALT FOG: The materials are selected so as not to be susceptible to the effects of Salt Fog.

DUST: The unit is sealed so as not to allow infusion of dust and sand into the working area.

LEAKAGE: (IMMERSION) The units are sealed and do have a positive internal pressure therefore preventing any contamination by water leakage.

Temperature- Humidity- Altitude: The unit is a positive pressured vessel and is not affected by the Altitude. The materials used in the construction of the coolers do not lend them to be affected by Temperature and Humidity.

11.0 A Reliability Test Plan will be submitted along with this procedure.

PHYSICAL CHARACTERISTICS DATA SHEET

Test Tech _____

Date _____
Project Eng. _____

REQUIREMENT

Record the following physical characteristics per paragraph 5.0 of this test plan.

Cooler S/N _____

Conforms to drawing number

SM-D-808551

Weight (2.5 pounds Max.)

_____ (initial)
_____ lb.

Cooler S/N _____

Conforms to drawing number

SM-D-808551

Weight (2.5 pounds max.)

_____ (initial)
_____ lb.

Cooler S/N _____

Conforms to drawing number

SM-D-808551

Weight (2.5 pounds max.)

_____ (initial)
_____ lb.

Test Sheet 1

INPUT POWER TEST DATA SHEET

Cooler S/N _____

Date _____

Test Tech _____

Project eng. _____

Step	TEST REQUIREMENT	INITIAL
1.0	Instrument cooler per paragraph 6.3 of this plan.	_____
2.0	Establish test set-up	_____
3.0	Verify power supply meets the voltage ripple requirements of paragraph 6.1.4 of this plan.	_____
4.0	Energize cooler and record the following data: <ul style="list-style-type: none"> o Input voltage _____ VDC o Starting current _____ Amps o Duration of starting current _____ Ms 	
5.0	Record data when the cold tip reaches 80K <ul style="list-style-type: none"> o Input voltage _____ VDC o Current _____ Amps o power _____ Watts 	
6.0	Apply sufficient heat load to maintain a cold tip temperature of 80K. Allow cooler to operate for an additional 30 min.	_____
7.0	At the end of 30 mins. record the following data: <ul style="list-style-type: none"> o Input voltage _____ VDC o Current _____ Amps o Power _____ Watts o Cold tip temp. _____ Degrees K o Applied heat load _____ Watts 	
8.0	De-energize cooler	

Comments: _____

Test Sheet 3

LEAK RATE TEST DATA SHEET

Test Tech _____ Project Eng. _____

Date _____ Time _____

TEST REQUIREMENT

Conduct Leak Rate Test per paragraph 6.1.1
of this plan.

_____ _____
Cooler S/N _____
Charged to operating pressure _____ (initial)
Measured leak rate (1.0×10^{-6} scc/sec air
equivalent at 23C ambient) _____

_____ _____
Cooler S/N _____
Charged to operating pressure _____ (initial)
Measured leak rate (1.0×10^{-6} scc/sec air
equivalent at 23C ambient) _____

_____ _____
Cooler S/N _____
Charged to operating pressure _____ (initial)
Measured leak rate (1.0×10^{-6} scc/sec air
equivalent at 23C ambient) _____

Test Sheet 2

ELECTRO-MAGNETIC RADIATION TEST
SUMMARY SHEET

Cooler S/N _____

Date _____

Test Tech _____

Project Engineer _____

Test Method	Title	Pass	Fail
RE 01	Radiated Emission/Magnetic Field 10 Hz to 10 KHz	_____	_____
RE02 BB	Radiated Emission/Magnetic Field 14 KHz to 1.0 GHz (Broadband)	_____	_____
RE02.1 NB	Radiated Emission/Magnetic Field 14 KHz to 10 GHz (Narrowband)	_____	_____
RS07	Radiated susceptibility, Electric Field, 14 KHz to 10 GHz (Modified)	_____	_____
CE01	Conducted Emissions/dc Power Leads 10 Hz to 50 KHz	_____	_____
CE04	Conducted Emissions/AC Power Leads 50 KHz to 50 Mhz	_____	_____

Conduct a Performance Test per paragraph 5.0 of this test plan and record the results.

Comments _____

Test Sheet 4

TEMPERATURE SHOCK TEST SUMMARY SHEET

Cooler S/N _____

Date: _____

Test Tech. _____

Project Eng. _____

Step	Date	Elapsed Time	Test requirement	Initial
1.0	_____	_____	Install coolers into test chamber	_____
2.0	_____	_____	Adjust chamber ambient to + 71C	_____
3.0	_____	_____	verify cooler has soaked for four hours	_____
4.0	_____	_____	Place cooler into test chamber that has been pre-cooled to -54C within 5 minutes from 71C	_____
5.0	_____	_____	Verify cooler has soaked for four (4) hours at -54C	_____
6.0	_____	_____	Place cooler into test chamber that has been pre-heated to 71C within 5 mins. of removing from -54C ambient.	_____
7.0	_____	_____	Verify cooler has soaked for for hours at +71C	_____
8.0	_____	_____	Place cooler into test chamber that has been pre-cooled to -54C within 5 mins. of removing from +71C ambient.	_____
9.0	_____	_____	Verify cooler has soaked for four hours at -54C	_____
10.0	_____	_____	Place cooler into test chamber that has been pre-heated to +71C within 5 mins. of removing from -54C ambient.	_____
11.0	_____	_____	Verify cooler has soaked for four hours at +71C	_____
12.0	_____	_____	Place cooler into test chamber that has been pre-cooled to -54C within 5 mins. of removing from +71C ambient.	_____

Temperature Shock Test Summary Sheet (Continued)

Step	Date	Elapsed Time	Test Requirement	Initial
13.	_____	_____	Verify cooler has soaked for four hours.	_____
14.	_____	_____	Adjust test chamber ambient to +23C	_____
15.	_____	_____	Verify test chamber Ambient is 23C	_____
16.	_____	_____	Visually inspect cooler for physical damage and record.	_____
17.	_____	_____	Conduct performance test per Para. 6.0 of this test plan	_____
			_____ Std. CC Helium/sec (record)	

Comments: _____

HIGH TEMPERATURE TEST SUMMARY SHEET

Cooler S/N _____

Date of Test _____

Testrr Tech _____

Project Eng. _____

Step	Date	Elapsed Time (Hr.-Min)	Test Requirement
1.0	_____	_____	Install the cooler into the test chamber instrumented per Para. 6.3
2.0	_____	_____	Adjust chamber ambient to +71C
3.0	_____	_____	Verify cooler has soaked for 48 hours at +71C
4.0	_____	_____	Operate the coolers in accordance with Para. 6.0 and record results.
5.0	_____	_____	Lower test chamber to standard room ambient (non-operating)
6.0	_____	_____	Visually inspect coolers for physical damage and record abnormal findings.
7.0	_____	_____	Conduct performance test at 23C per Para. 6.0. and record results.

_____ Std. CC Helium/Sec. (Record)

Comments: _____

LOW TEMPERATURE TEST SUMMARY SHEET

Cooler S/N _____

Date _____

Test tech _____

Project Eng. _____

Step	Date	Elapsed Time (Hour/Min.)	Test Requirement
1.0	_____	_____	Install cooler into test chamber as per Para. 6.3.
2.0	_____	_____	Adjust test chamber to -57C
3.0	_____	_____	Verify cooler has soaked for 48 hours at -57C
4.0	_____	_____	Raise the temperature to -40 and allow coolers to stabilize.
5.0	_____	_____	Operate coolers in accordance to para. 6.0 and record results.
6.0	_____	_____	Raise test chamber to standard room ambient +23C (non-operating)
7.0	_____	_____	Visually inspect coolers for any physical damage and record.
8.0	_____	_____	Conduct Performance test at +23C and record

_____ Std. CC Helium/Sec. (record)

Comments: _____

LOW TEMPERATURE TEST SUMMARY SHEET

Cooler S/N _____

Date _____

Test tech _____

Project Eng. _____

Step	Date	Elapsed Time (Hour/Min.)	Test Requirement
1.0	_____	_____	Install cooler into test chamber as per Para. 6.3.
2.0	_____	_____	Adjust test chamber to -57C
3.0	_____	_____	Verify cooler has soaked for 48 hours at -57C
4.0	_____	_____	Raise the temperature to -40 and allow coolers to stabilize.
5.0	_____	_____	Operate coolers in accordance to para. 6.0 and record results.
6.0	_____	_____	Raise test chamber to standard room ambient +23C (non-operating)
7.0	_____	_____	Visually inspect coolers for any physical damage and record.
8.0	_____	_____	Conduct Performance test at +23C and record

_____ Std. CC Helium/Sec. (record)

Comments: _____

MECHANICAL SHOCK TEST SUMMARY SHEET

Cooler S/N _____

Date _____

Test Tech _____

Project Engineer _____

Step	Requirement	Initial
1.0	Verify Shock Machine is calibrated	_____
2.0	Install instrumented cooler with power leads only onto the shock table. (X axis)	_____
3.0	Energize cooler and operate with no thermal load or instrumentation on the coldfinger.	_____
4.0	Apply two shocks in the positive X axis	_____
5.0	Apply two shocks in the minus X axis	_____
6.0	Change the cooler into the Y axis	_____
7.0	Apply two shocks in the positive Y axis	_____
8.0	Apply two shocks in the minus Y axis	_____
9.0	Change cooler into the Z axis	_____
10.0	Apply two shocks in the positive Z axis	_____
11.0	Apply two shocks in the minus Z axis	_____
12.0	De-energize cooler and inspect for physical damage. Record results.	_____
13.0	Conduct performance test per para 6.0	_____

_____ Std. cc helium/sec

Comments _____

Test Sheet 8

MECHANICAL VIBRATION TEST SUMMARY SHEET

Cooler S/N _____

Date of Test _____

Test Tech _____

Proj. Eng. _____

Step	Test Requirement	Initial
1.0	Mount cooler onto vibration table in the X axis.	_____
2.0	Energize coolers and allow cooldown for 10 minutes.	_____
3.0	Energize vibration machine and conduct a resonance search at an input level of 1g from 5- 500 Hz.	_____
Resonances: 1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ 7. _____		
4.0	Select the four most severe resonances recorded and perform a resonance dwell for 20 minutes frequency levels specified.	_____
5.0	Energize vibration machine in accordance to the vibration profile.	_____
6.0	Allow coolers to vibrate in this axis for 120 minutes	_____
7.0	De-energize vibration machine and coolers	_____
8.0	Remove coolers from vibration machine and inspect for physical damage.	_____
9.0	Mount the coolers in the Y axis and repeat steps 2.3 and 4	_____
10.0	Energize the coolers and allow cooldown for 10 minutes	_____
11.0	Energize the vibration machine in accordance with the appropriate vibration profile.	_____
12.0	Allow the cooler to vibrate in this axis for 120 minutes.	_____
13.0	De-energize vibration machine and remove the coolers. Inspect the coolers for any physical damage.	_____
14.0	Mount the coolers in the Z axis. instrumented, repeat steps 2.3 and 4 in the Z axis.	_____
15.0	Energize the coolers and allow to cooldown for 10 minutes.	_____

Step	Test Requirement	Initial
16.0	Energize the vibration machine with the appropriate vibration profile.	_____
17.0	Allow the coolers to vibrate in this axis for 120 minutes	_____
18.0	De-energize the vibration machine and remove the coolers. Inspect the coolers for any physical damage.	_____
19.0	Conduct a performance test per paragraph 6.0	_____

Leak Test: _____ Std cc helium/sec

Comments _____

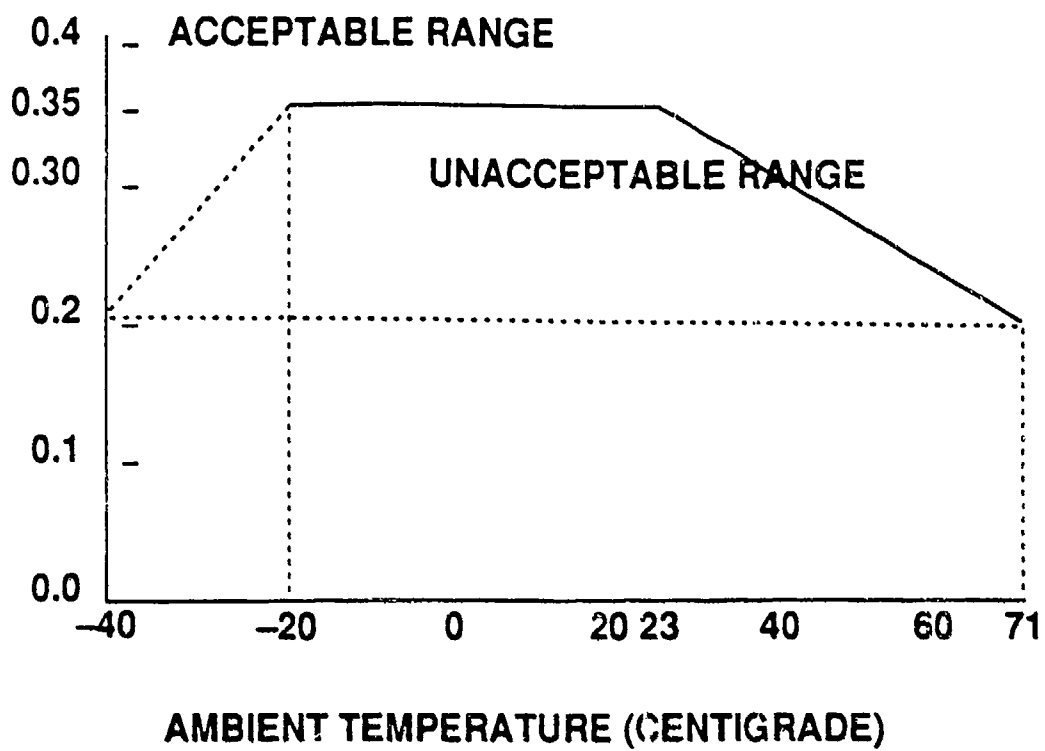


Figure 1. Cooling Capacity

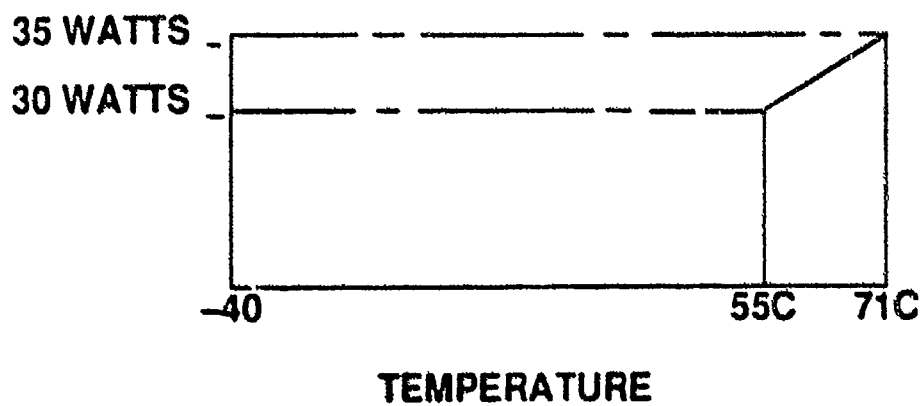


Figure 2. Input Power

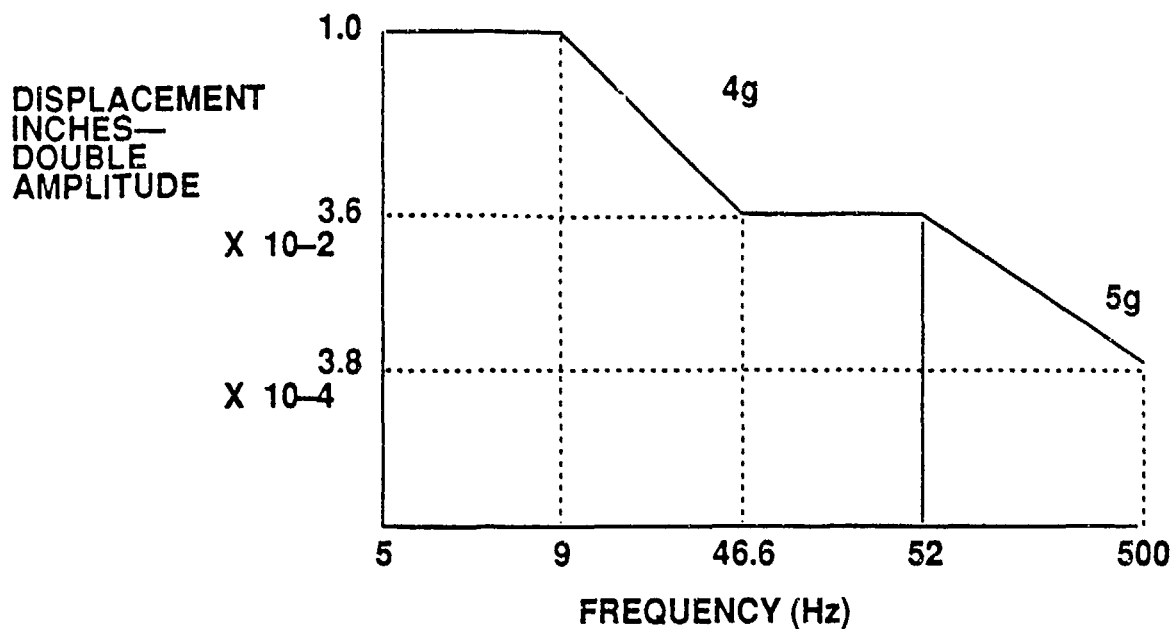


Figure 3. Vibration Test Profile

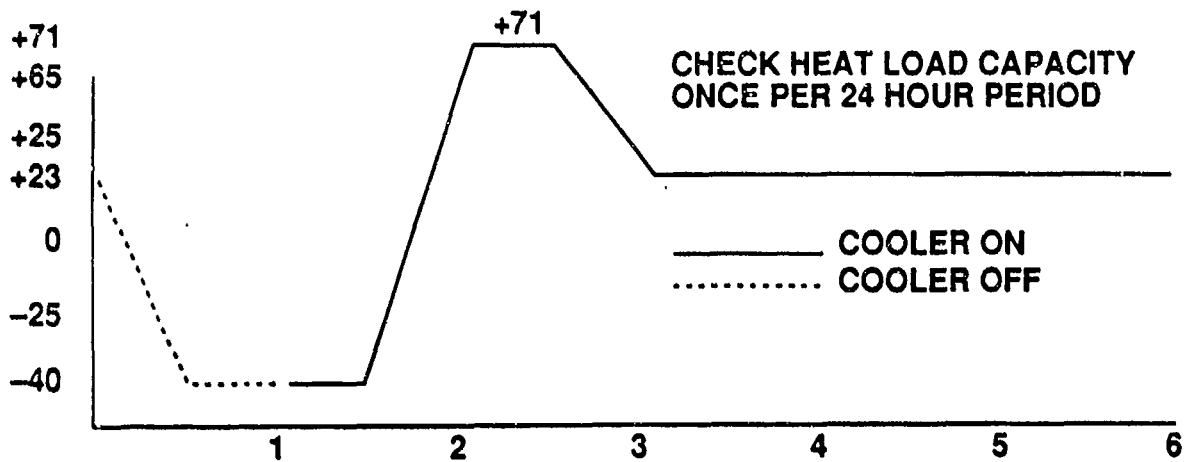


Figure 4. Reliability Test Cycle

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